July 19, 1973

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Rating	EM	SCR
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10V-250A	1,200	1,400
10V-500A	1,600	2,000
20V-125A	1,050	1,200
20V-250A	1,275	1,500
20V-500A	2,050	2,650
30V-100A	1,050	1,200
30V-200A	1,450	1,800
40V-60A	950	1,100

	Price	
Rating	EM	SCR
40V-125A	$1,300	$1,600
40V-250A	1,975	2,500
50V-200A	1,975	2,500
80V-30A	950	1,110
80V-60A	1,200	1,500
100V-100A	1,975	2,500
120V-20A	975	1,300
120V-40A	1,200	1,500

	Price	
Rating	EM	SCR
160V-15A	$ 950	$1,100
160V-30A	1,300	1,600
160V-60A	1,975	2,500
250V-10A	950	1,100
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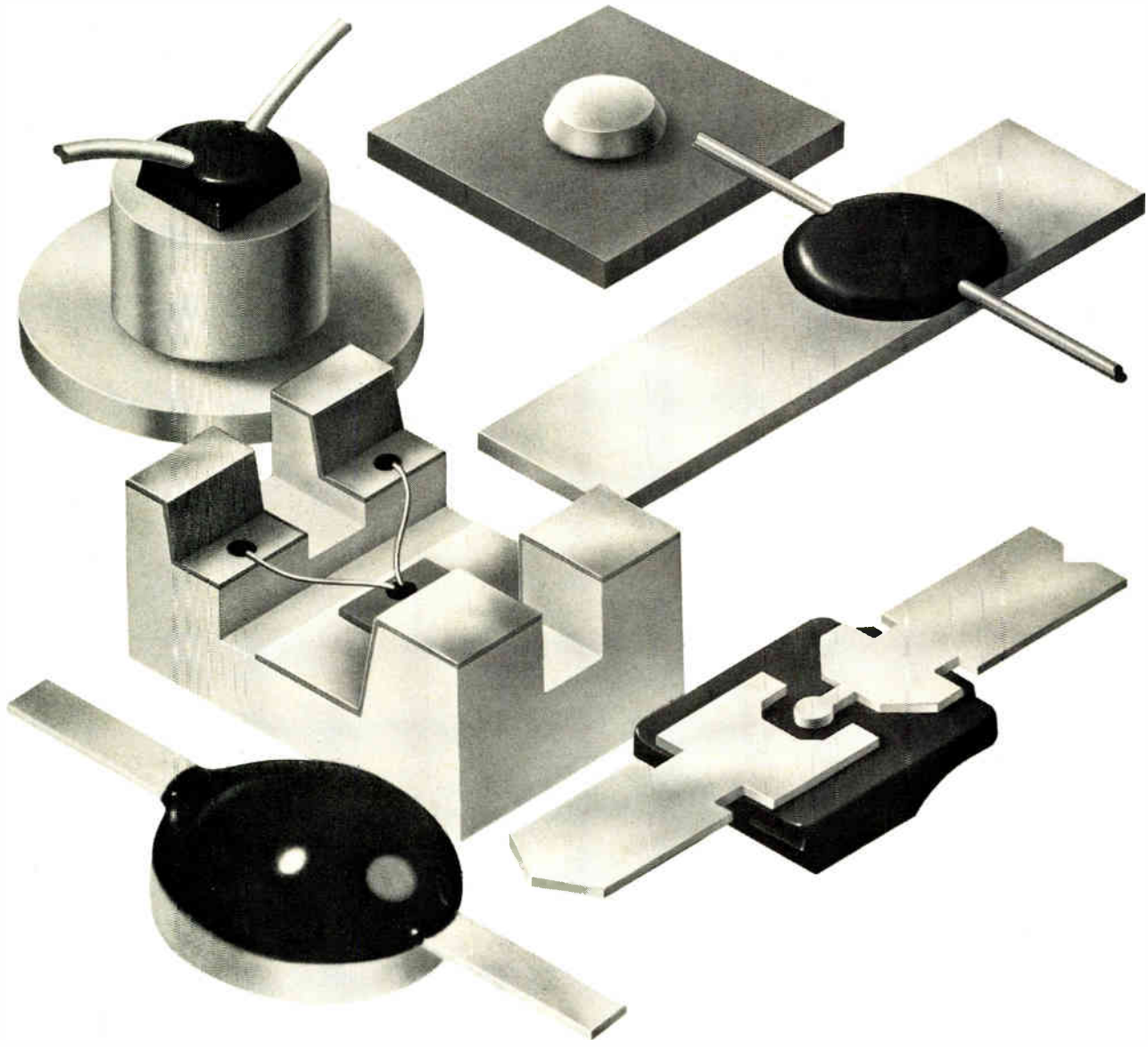

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Electronics
The International Magazine of Electronics Technology
Vol. 46, No. 15 •July 19, 1973

Highlights

The cover: The robot's arrival in industry, 93
Industrial robots are only gradually being accepted on assembly lines, and few as yet are electronic. But both their popularity and their electronic content are starting to soar, now that minicomputers are available to control whole groups of robots from a central point. Cover illustration is by Art Director Fred Sklenar.

Earth terminals are taking off, 69
The smaller satellite systems that are being set up to supplement the global network are creating a vast new demand for simple, relatively inexpensive earth terminals.

Majority logic joins the AND OR crowd, 107
At last available in economical C-MOS form, majority logic considerably extends the logic designer's power since it simplifies the realization of otherwise complex digital functions.

Minicomputers check out aircraft elements, 120
As part of modular systems for testing aircraft subsystems, minicomputers collect and process measurements on everything from propulsion to flight control. This is the sixth article in the series about "Minicomputers in action."

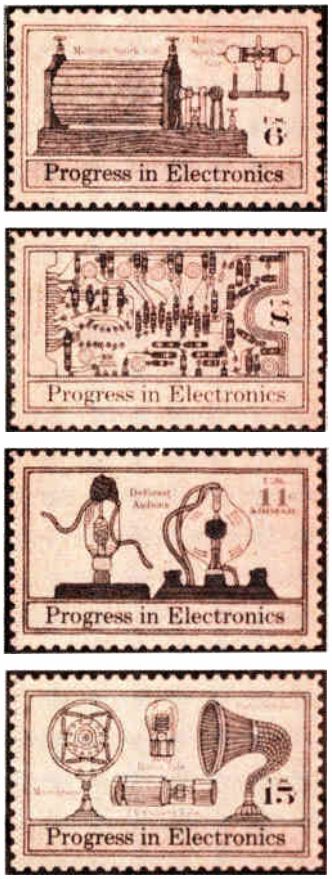
And in the next issue . . .
Special report on semiconductor memories . . . specifying sample-and-hold amplifiers . . . shunt regulation and the design of more efficient power supplies.

Electronics

Publisher's letter

Progress in Electronics—from Marconi's spark gap, which sent the first transatlantic radio message, to transistors—is the subject of a series of postage stamps issued on July 10, the fourth anniversary of man's first step on the moon.

And that's a fitting day, because the Space Age owes its very existence to the developments of electronics, a field that didn't have a name until this magazine gave it one back in 1930.



Actually, the stamps depict antiques and items that were already old a decade ago. And the progress made in just that decade—from microcircuits and microcomputers to solid-state imaging and optical communications—is setting the stage for some extraordinary progress in electronics—and changes in the way we live. In fact, electronics may do away with the stamps.

Robots—the subject of our special report starting on page 93—as a word conjures up visions of ambulatory automatons, like Russia's lunar vehicle or some science fiction monster. But, says one builder of industrial robots: "The devices we build are so much simpler that the word 'robot' is a misnomer. No one really knows what a robot is or how it can help him. But if I say I have a 'smart' manipulator that can be programed to go through a pattern of repetitive motions, they know what I'm talking about."

As Industrial Editor Alfred Rosenblatt points out in the report, more and more jobs are being turned over to these manipulators, which depend on electronics to guide their motions. Indeed, some of the machines do their appointed tasks with an uncanny expertise. One machine shown at a recent Zurich symposium picked up beer cans put anywhere on a table and poured the contents into mugs for thirsty showgoers. Light beams across the tabletop were interrupted by the can, giving the machine data on where to find the can. Given more time to set up the machine, its developer said, it could have opened the can, too, and then put the empty beer can away in a case for later disposal. And then pause to take a drink?

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Circle 5 on reader service card

Readers comment

Etching pc-board sandwich

To the Editor: The article, "Etching pc-board sandwich eliminates discrete resistors," by Al Ertel and J. R. Mars [*Electronics*, May 10, p.109], reminds me of the 1967 Nepcon paper by Cinch-Graphik on "Thin-Film Resistors Using Conventional Circuit-Board Substrates." Since the etchant resist may be either a photoresist or a resist ink, how is either process accomplished with zero setup time? Is there no mask alignment for photoresist? If resist ink is used, how is it applied? Setup time is needed to screen print-fired films (Table 2), but is none required to screen print-resist inks?

R. R. Bigler
RCA
Camden, N. J.

■ ***Co-author Ertel replies:*** *The only similarity between the defunct Cinch-Graphik system and the Micaply Ωhmega technology is that both provide thin-film resistors on conventional board substrates. The important differences are these:*

■ *The Cinch-Graphik system was additive, and resistor patterns were plated onto the epoxy-glass substrate, but the Micaply Ωhmega system is completely subtractive. The board is provided as a laminate ready to be selectively etched.*

■ *The Cinch-Graphik process has a negligible peel strength. Micaply Ωhmega has a minimum peel strength after solder float of 5 pounds per inch, just slightly under that of conventional pc boards.*

Since the information presented in Table 2 is quite concise, comments on processing were omitted. The cost comparison was based upon a moderate-capacity thick-film facility vs a similar pc-board facility. Setup time is required for thick film where no alternative but screening is available. We used as reference our own facility. Our panels are uniformly 10 in. by 12 in., regardless of the number of circuits to be produced, and photoresist artwork is used universally (no resist ink is used). No setup time is required because circuit boards are continuously being processed, and switching photomasks merely involves slipping the proper mask onto the positioning pins.

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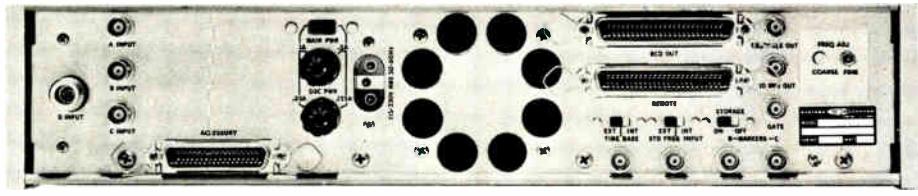

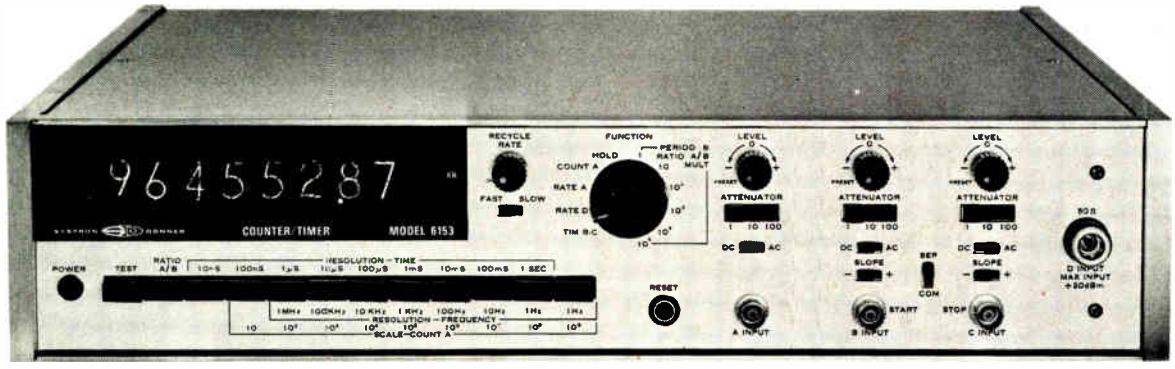

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40 years ago

From the pages of Electronics, July 1933

By imbedding the two grid condenser plates of an oscillator in a mass of rubber undergoing vulcanization, one rubber company has been able to follow closely the progress of the vulcanization reaction. As sulphur added to the rubber, the dielectric constant of the mass changed sufficiently to cause frequency variations in the oscillator circuits which could be interpreted in amounts of combined sulphur.

Oscillations of various frequencies are also found to have catalytic effects on many of the more common chemical reactions.

To set up a positive standard for depth of printing, an American Photoelectric reflectometer has now been used with considerable experimental success. With this instrument a two-inch circle of the printed page is compared with the same paper unprinted or blank. Taking the blank paper as 100 per cent, a "dark" or heavy-inked page gives a reflecting factor of 85 per cent; medium gives 86½ per cent; and very light inking gives 88 per cent. Of course the sample included in the two-inch circle must in each case be of fairly solid and comparable type composition.

Certainly that was an admirable proposal by the I.R.E. to have a percentage set aside out of manufacturers' gross sales, to be applied to research and scientific study in the art. Five per cent has been suggested, and this would not be too much, although at the present economic juncture, it may be difficult to secure approval of such a figure. On the other hand, such an amount has not been far from that assigned by notably successful corporations for their research funds.

A five-per-cent fund for research, imposed on all manufacturers of radio and allied products, would have many interesting and beneficial effects. It would aid technical employment and advance the art. And it would kill off the gyp manufacturers or force them to contribute to the art which they now benefit from but do not support.

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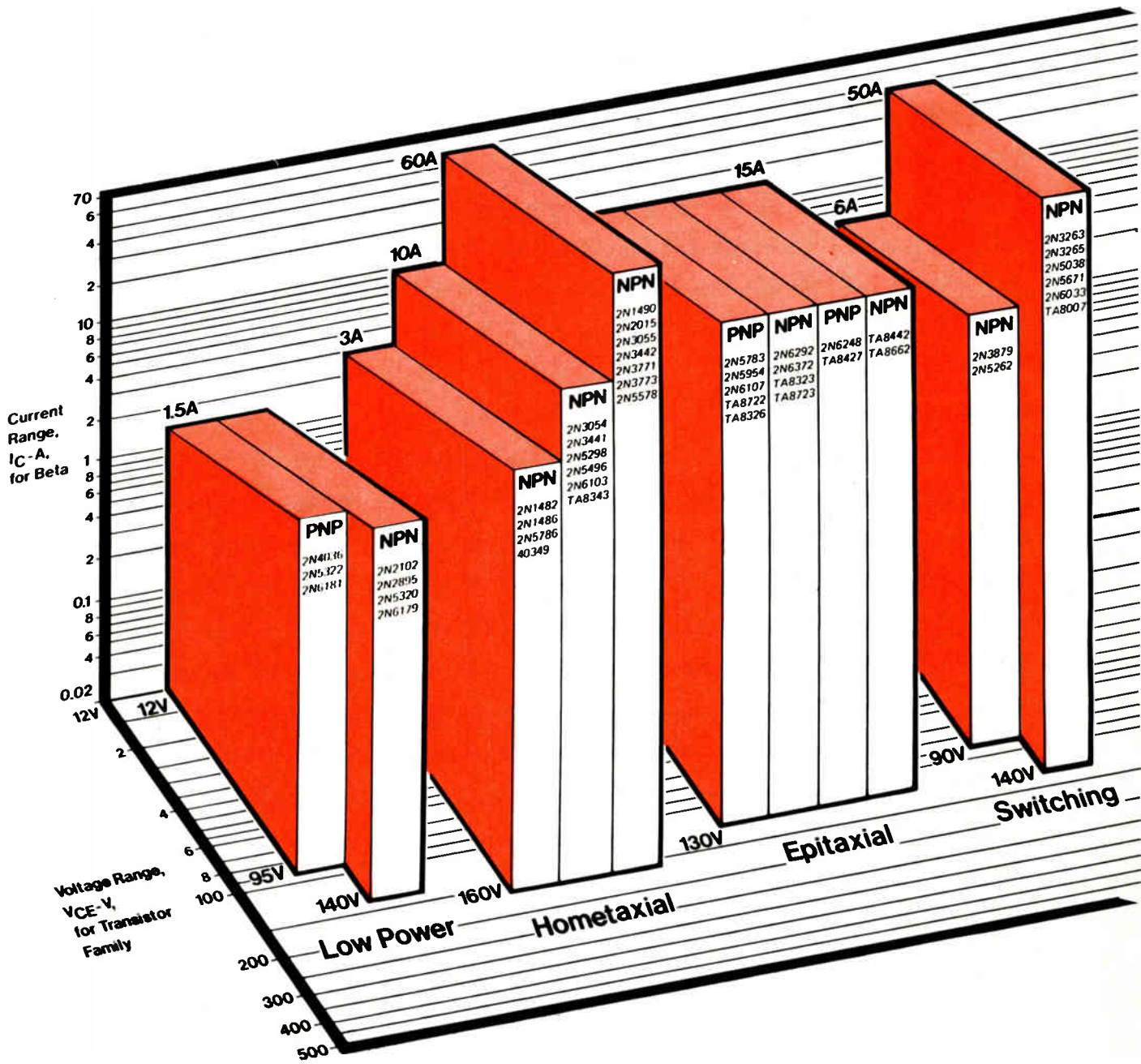

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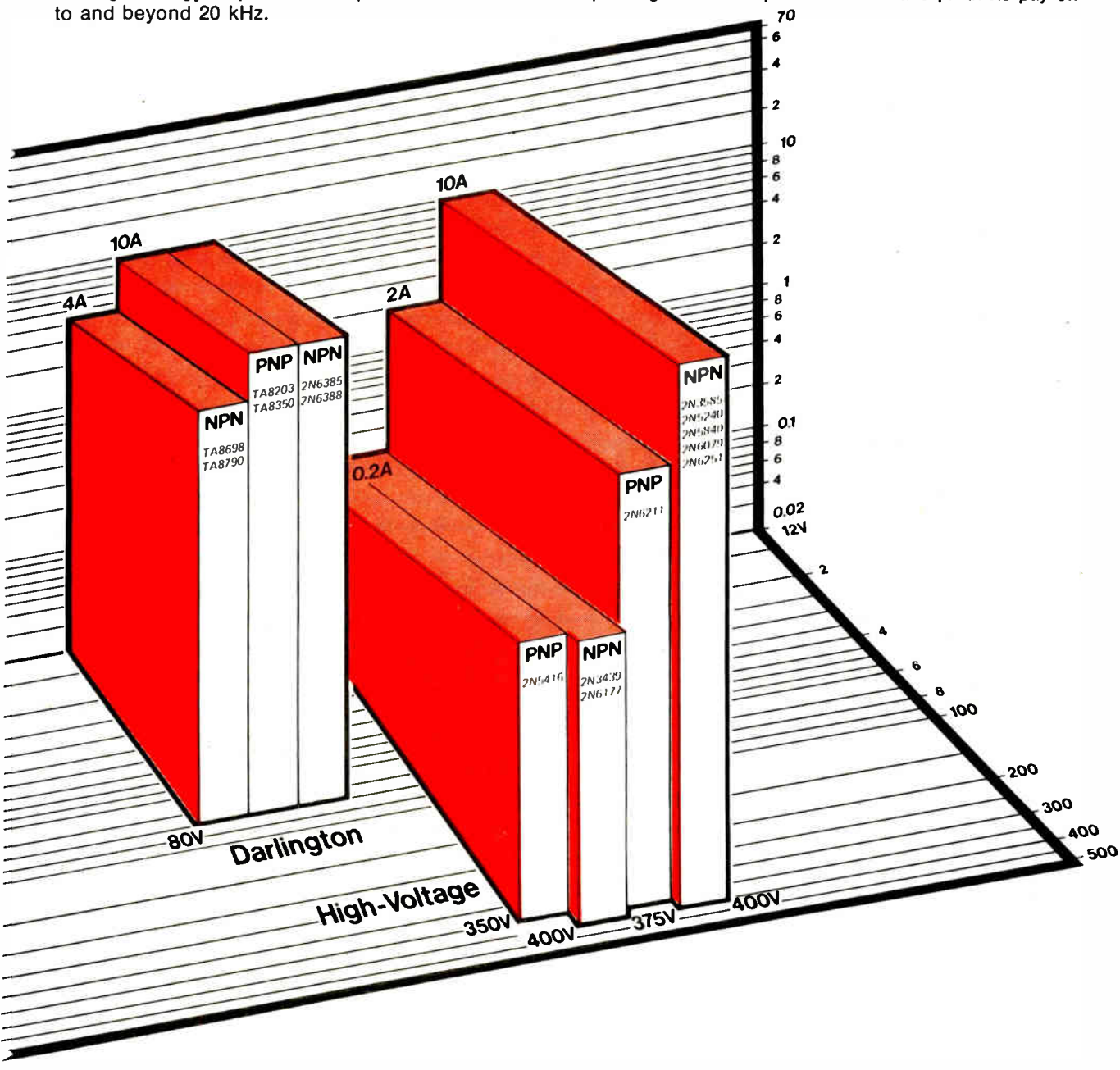

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People

Preventing growing pains is Nee's challenge at CMI

When a company hires several executives at once, it can mean a shakeup, but in the case of Cambridge Memories Inc., the appointments result from rapid growth. Sales in the past three years have grown so that the Concord, Mass. manufacturer of computer memory systems expects $10 million this fiscal year and perhaps $20 million next year.

Paul C. Nee, vice president of corporate planning, Steven Barouxis, corporate controller, and Curtis L. Collison, director of administration, are expected to provide "the more mature management product I think the company needs," says Richard Egan, vice president for marketing. He hopes that by adding new executives before the need for them is acute, "no one will ever know we needed them."

While the position of controller is not new, Barouxis will be "trying to implement procedures and practices that won't snarl us up when we get large," Egan says. Collison, in his newly created post, is in charge of facilities planning, capital requirements, and corporate services.

Pivotal. Corporate planning is also a new function, and perhaps the most important. Nee sees his role as "helping to lay down strategy to internally control operations financially, operations-wise, and with new products." His first job will be to help CMI establish an internal management system. "When a company goes beyond the $10–$20 million mark it's a new ball game," he says.

However, Nee thinks CMI has planned for its growth well in advance, although he does see a need for more middle management in the next year as the company grows even larger. And Nee is able to speak with some authority; he has known founder Joseph F. Kruy since both worked at Honeywell, and kept an eye on the company.

Nee also has the advantage of coming to CMI with personal experience in a fast-growing company.

Nee. Adding a discipline.

Starting with Honeywell's design team in the late 1950s, when its computer operations were very small, he worked on the D1000 computer project. From there he moved on to positions in engineering, product planning, and market planning.

In the mid-1960s he joined General Electric, working on GE's master plan for computers, and for the past two years was director of corporate development at American Optical Co. When the opportunity came to get back into the computer business, he decided to take it. "I have been through the whole product cycle," he says, "and I have seen small programs become large programs." At CMI he has an opportunity to go through the cycle once more.

Fresh CATV competition drives Jerrold's Firestone

Two subjects stir the competitive drive of William L. Firestone, Jerrold Electronics Corp.'s new president: maintaining his company as the number one manufacturer in cable television—and tennis. A dedicated tennis player, the 52-year old Firestone hates to lose.

The same can be said for his view of heading Jerrold Electronics, Horsham, Pa., a General Instrument company, which has dominated the CATV industry for 20 years. But now that cable operators are expanding into the top 100 TV markets, Jerrold's dominion is being challenged.

Adamant. Firestone's reaction is about the same as when at match point in a tough tennis tournament—single-minded concentration. Asked if it is realistic to expect Jerrold to hold the 40% to 50% control

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On the SANDERS assembly line, Nashua, New Hampshire: Ed Minich, Supervisor, Electronic Design Group at SANDERS, holding a printed circuit board containing MOSTEK MK4006P 1K RAMs; on the right, Gordon Hoffman, Applications Manager for MOSTEK Corporation.

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of the CATV market it now enjoys, he brings his fist down for emphasis: "We have the dominant position, and we intend to keep it. We can continue to be the leader by investing in the future."

Products heading Jerrold's lineup include a new modular information-distribution system, Starline 300, with optional status-monitoring equipment, and StarCom 36, a 36-channel set-top converter with three 12-channel bands that can be connected separately as more channels are needed.

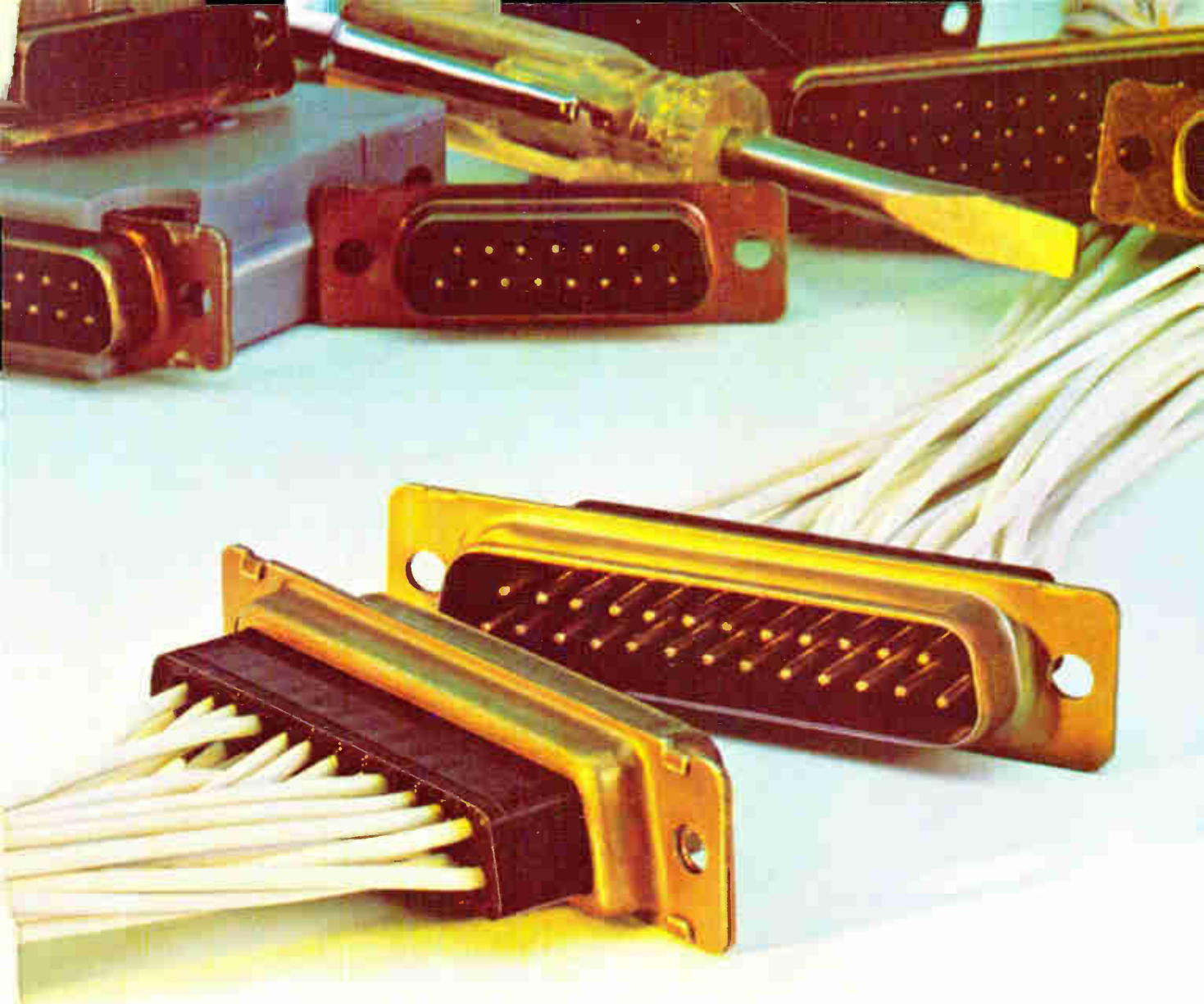
A third new product is an advanced two-way CATV system, called Communicom. The interactive system has a home terminal for sending and receiving from the cable operator's central head end.

Firestone has 20 years in two-way radio development, being something of a pioneer with Motorola. "At the time I started, Motorola's radio communications operation probably consisted of 12 people—and I was number 12; sweeping up, running for sandwiches, and so on," he recalls.

Since then, Firestone has earned three degrees: BSEE (Colorado), MSEE (Illinois), and a Ph.D. in electrical engineering (Northwestern). He gained management experience at Hallicrafters Co., Whittaker Corp. and Motorola before joining GI as vice president and general manager of the F.W. Sickles division.

"I view the cable industry much as the two-way radio industry was 15 to 18 years ago—one company on top, rapidly growing, not a mature industry. That's why I feel at home here," he observes.

Firestone. Keeping the ball in his court.



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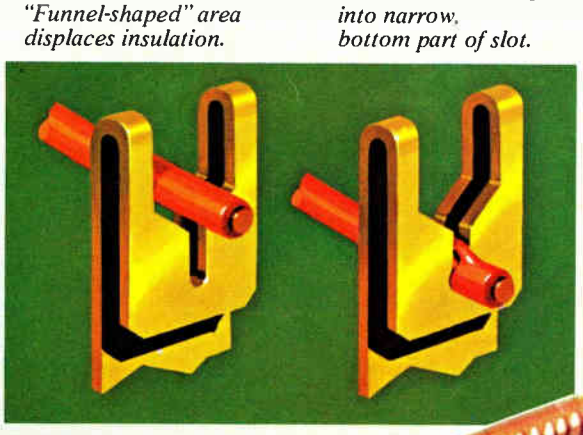
Connectors can be supplied preloaded as desired or empty and ready for loading. A rear-release plastic retainer eliminates the need for spring clips.

If you're going rack and panel, reasons to go with

More and more electronic equipment is being designed with "slide-out" circuitry. The principal virtue of the technique is that it permits greater economy of production through mechanized assembly of individual system modules. And economy with reliability is the name of the game with AMP connectors. Economy that has as its basis automated machine termination and wiring of individual contacts and posts.

A good example is the CHAMP 25 pair connector, a product that has created widespread interest for use in data and communications links and in computer and telecommunications equipment.

The CHAMP connector, like many AMP connectors, has a unique method of termination which is the real basis for low applied cost. The CHAMP connector employs a ramp-like contact with built-in insulation cutting bar which permits an unstripped solid wire—and certain kinds of stranded wire—to be fully terminated at high speed by a semiautomatic machine. In addition to being more economical, CHAMP connector



Egg-crated cavities in rugged, one-piece AMPLIMATE connector housing provide insulation without the need for heat-shrink sleeves.

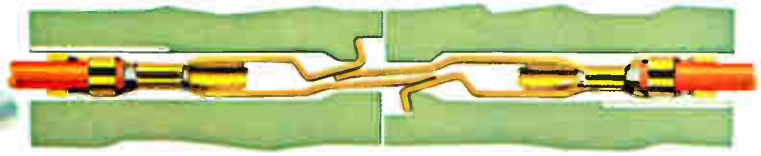
here are some economical AMP connectors.

terminations offer excellent density and vibration resistance. Individual contacts may be removed and replaced easily with minor disruption to total connector interfaces.

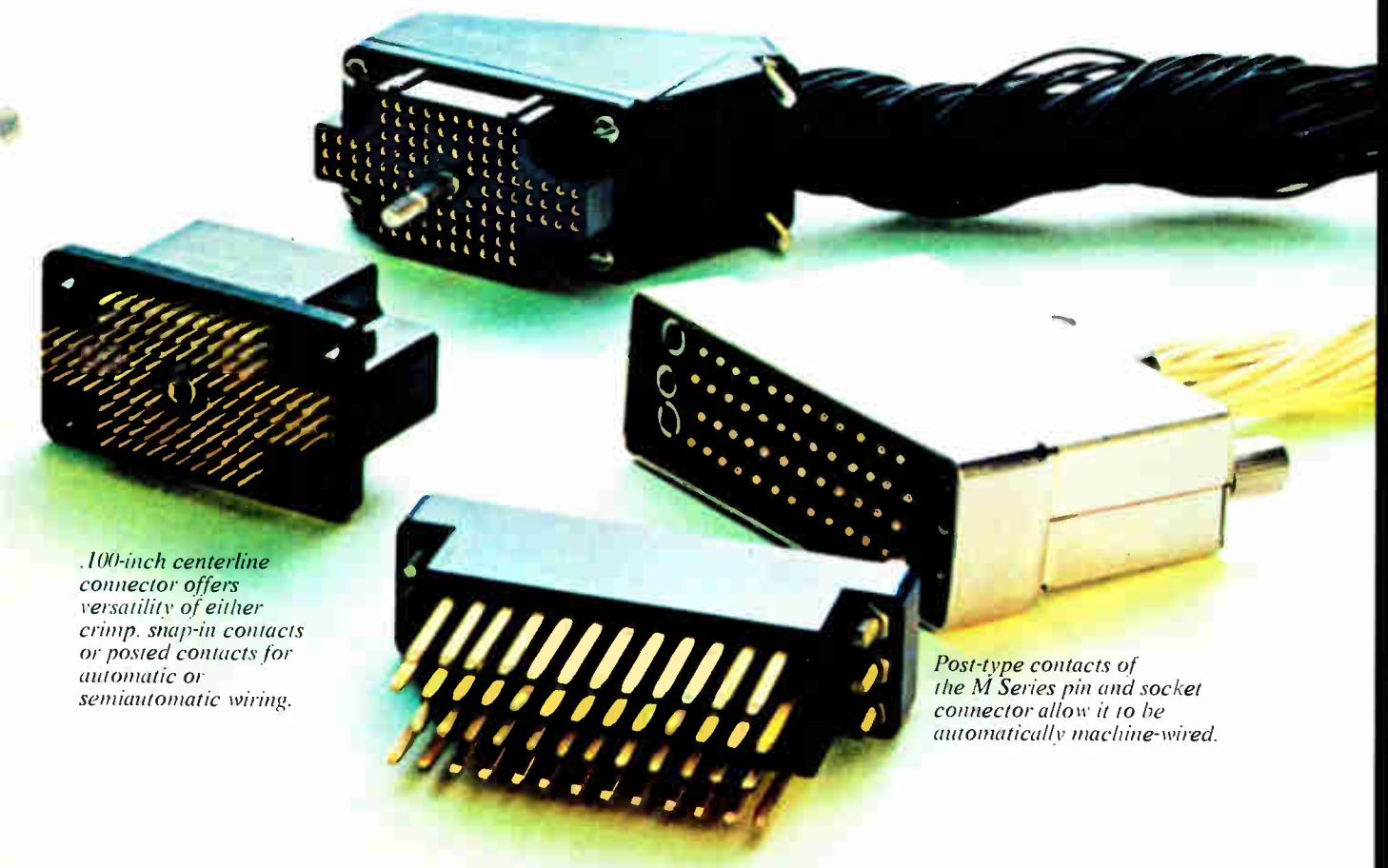
Another way to realize economy is through the use of hermaphrodidic contacts. Since both connector halves use the same contact, inventories are reduced. Two cases in point are the AMP miniature DUALATCH connector and the AMPLIMATE connector. Not only are their self-wiring contacts hermaphrodidic; they can also be applied by high-speed, automated machines.

And economy is matched by versatility, because of the compactness and wide range of housing configurations.

Machine wiring is still another way to get economical interconnections. Both the AMP High Density Rectangular connector and the AMP M Series connector fit into this category. Both are available with post-type contacts which can be automatically machine-wired. In addition, each can be selectively loaded, so that even further economies can be realized.



Positive wiping action and gold-over-nickel plating of miniature DUALATCH contact ensure excellent electrical and mechanical performance.



.100-inch centerline connector offers versatility of either crimp, snap-in contacts or posted contacts for automatic or semiautomatic wiring.

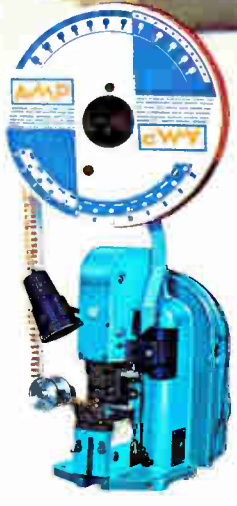
Post-type contacts of the M Series pin and socket connector allow it to be automatically machine-wired.

"Economy" can mean many things to many people.

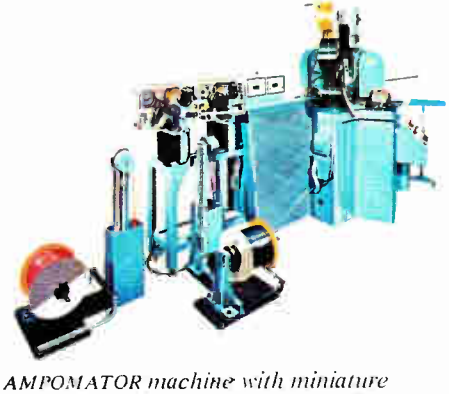
With AMP products it means low applied cost. Which comes about through better, faster, automated wiring and termination methods, often providing even better, more consistently reliable performance. With no sacrifice in product quality. Design and production knowhow provides little extra touches like redundant spring tines for greater retention, special selective platings for reasonable cost, and positive wiping contacts to ensure good, reliable electrical performance for thousands, even tens of thousands, of matings.

Finally, you get a worldwide sales and service organization that ensures customer satisfaction and product standards wherever electrical and electronic connectors are used.

If you'd like specific information about any of the products or machines in this advertisement or about the company as a whole, please write AMP Industrial Division, Harrisburg, Pa. 17105. Or circle Reader Service Number 160.



AMP-O-MATIC stripper/crimper machine strips wire and attaches contact during each machine cycle—at rates up to 1500 an hour.



AMPOMATOR machine with miniature applicator can produce up to 5700 doubly-terminated leads an hour.

AMP
INCORPORATED

For the really tough applications, OEM's like Magnavox choose HP.

We all know what collisions at sea can mean to a company's reputation. That's why Magnavox sought reliability above all else in choosing the HP 2100A minicomputer for its all-weather, worldwide Satellite Navigation System. It brings added safety and economy to the operation of large ocean-going vessels. Including the new deep-draft supertankers which must navigate through narrow channels.

In fact, reliability is one of the major reasons why OEM's are using Hewlett-Packard's line of thoroughly modern minis for their systems. But reliability is not enough. Magnavox, like any OEM, also must be competitive in their market place. Hewlett-Packard's 2100A solved their need. Competitive? Just try us!

And modular. So compact and rugged that entire Magnavox systems can be transferred from one vessel to another. Adaptable, too. Commercial transports, oil tankers, passenger ships, exploration vessels for the Navy and Coast Guard. Virtually every large ship plying the waterways of the world can use this system to pinpoint instantly its position anywhere in the world. Night or day.

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Are you laying your reputation on the line without an HP mini? Call your local HP sales engineer for details on fitting the right mini into your system. Or write Hewlett-Packard, 1501 Page Mill Road, Palo Alto, California 94304; Europe: P.O. Box 85, CH-1217 Meyrin 2, Geneva, Switzerland; Japan: YHP, 1-59-1, Yoyogi, Shibuya-Ku, Tokyo, 151.

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Meetings

International IEEE G/AP Symposium and USNC/URSI Meeting: IEEE, U. of Colorado, Boulder, Aug. 21–24.

17th Annual Meeting and Equipment Display: SPIE, Town and Country, San Diego, Calif., Aug. 27–29.

European Microwave Conference: IEEE, IEE, Brussels University, Belgium, Sept. 4–7.

Western Electronic Show & Convention (Wescon): Wema, Civic Auditorium and Brooks Hall, San Francisco, Sept. 11–14.

Third European Solid-State Device Research Conference: IEEE et al., Munich Technical University, West Germany, Sept. 18–21.

International Conference on Engineering in the Ocean Environment: IEEE, Washington Plaza, Seattle, Sept. 25–28.

International Exhibition of Industrial Electronics (Elettronica 2): Turin, Italy, Sept. 29–Oct. 8.

International Electron Devices Meeting: IEEE, Sheraton Park, Washington, D.C., Oct. 7–10.

Electronic and Aerospace Systems Convention (Eascon): IEEE, Sheraton, Washington, Oct. 8–10.

Optical Society of America Annual Meeting: OSA, Holiday Inn—Downtown, Rochester, N.Y., Oct. 9–12.

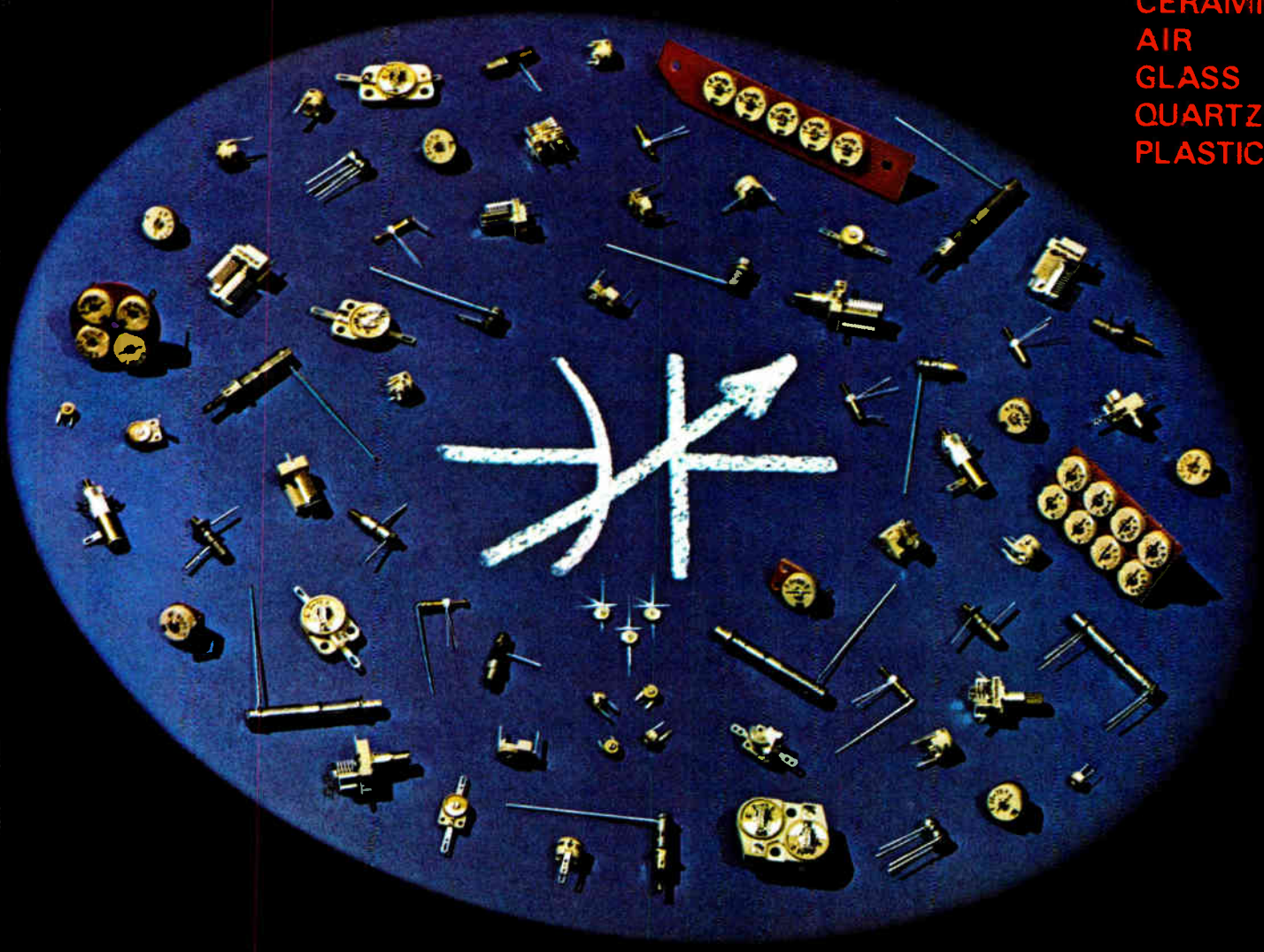
International Telemetering Conference/USA: ITC, Sheraton Northeast, Washington, D.C., Oct. 9–11.

Canadian Computer Show & Conference: CIPS, Exhibition Park, Toronto, Oct. 16–18.

American Society for Information Science Annual Meeting: ASIS, Hilton, Los Angeles, Oct. 21–25.

Connector Symposium: Connector Study Group, Cherry Hill Inn, Cherry Hill, N.J., Oct. 24–25.

CERAMIC
AIR
GLASS
QUARTZ
PLASTIC



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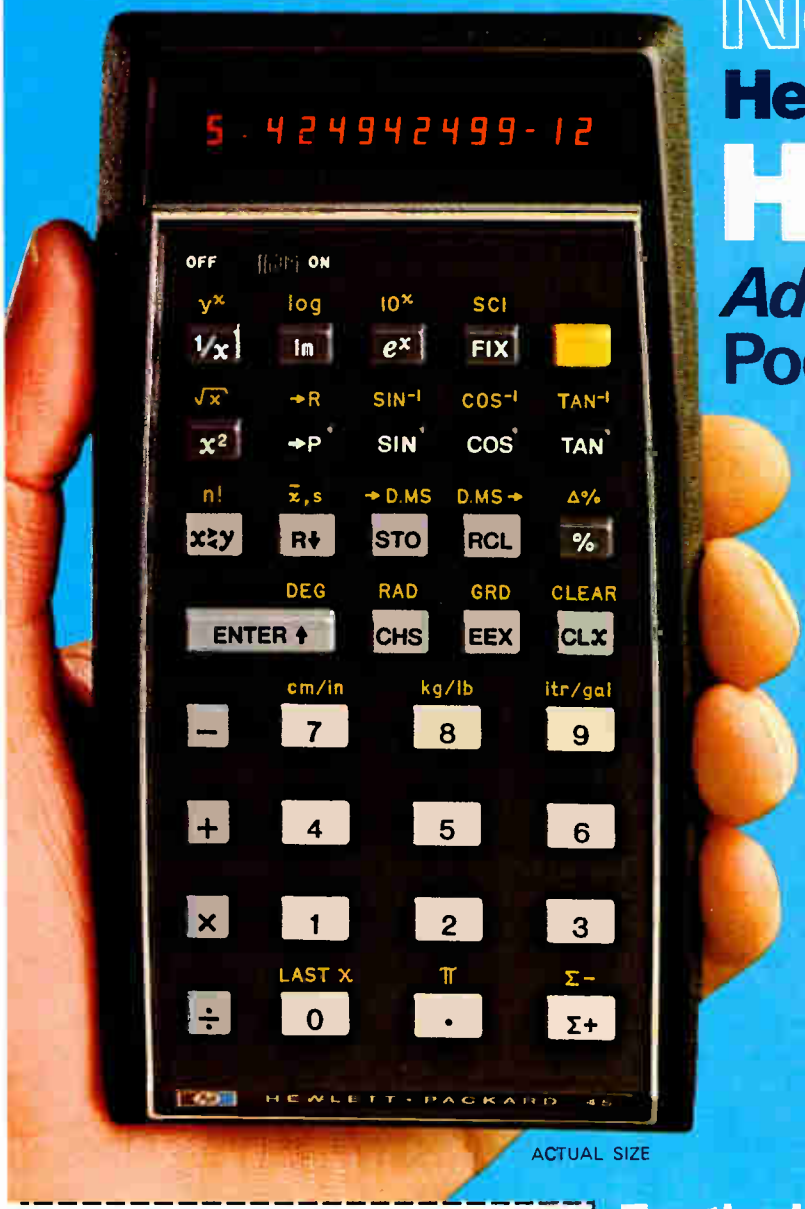

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The new HP-45 lets you solve even the most complex scientific and engineering problems in seconds—anywhere, any time—just by pressing a few keys!

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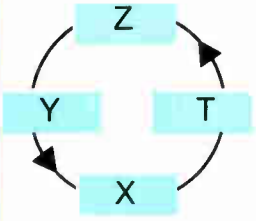
Gold "shift" key doubles the function of 24 keys . . . helps give the HP-45 increased capability with no increase in size! Primary functions are labeled on the keys, alternate functions above. Gold key lets you shift from one to the other.

Display formatting in fixed decimal or scientific notation . . . at the press of a key. And you can round off answers to any number of digits (0 to 9) displayed after the decimal point in either mode. Full accuracy is always maintained internally.



Operational stack has 4 registers . . . for automatic storage and retrieval of intermediate solutions. The stack design permits review of stored data at any time.

9 additional memory registers are addressable . . . can be used for storage and retrieval of data, or to perform register arithmetic. A 10th ("Last X") register lets you recall last input argument for error correction or for multiple functions of same argument.

Trig functions may be performed in any of 3 selectable angular modes . . . degrees, radians or grads. Decimal angles are calculated in whichever mode is specified. The HP-45 also computes natural and common logarithms, as well as antilogarithms.

Permanent U.S./metric constants permit instant conversion . . . for rapid calculation of problems involving length, weight or volume. And you get 10-digit accuracy!

Instant conversion from an angle in any angular mode to degrees/minutes/seconds (*e.g.*, 45.89° = 45° 53' 24") . . . with the answer automatically rounded to the nearest second. Or convert from D/M/S to the equivalent decimal angle.

Instant conversion from polar to rectangular coordinates . . . or vice-versa. And vector calculations are simple when you also use the Σ+ key to simultaneously accumulate two coordinates.

Factorial function allows rapid calculations of combinations and permutations . . . to reduce problem-solving time to seconds. You can quickly find the factorial of positive integers.

Statistical analysis is easier . . . because the Σ+ key provides a running total when summing numbers, keeps track of the number of entries, and automatically computes the sum of the squares. The x̄,s key calculates the arithmetic mean and the standard deviation.

Beyond the basic four functions (+ − × ÷), the HP-45 is pre-programmed to:

Perform trigonometric functions:
- Sine
- Arc sine
- Cosine
- Arc cosine
- Tangent
- Arc tangent

Perform logarithmic functions:
- Common logarithm
- Natural logarithm
- Common antilogarithm
- Natural antilogarithm

And perform:
- Serial calculations
- Mixed serial calculations
- Chain calculations
- Mixed chain calculations

Calculate:
- The square root of the number displayed
- The square of the number displayed
- The reciprocal of the number displayed
- The raising of any positive number to any power
- The factorial of positive integers
- Percentage and percent differences
- Sum of the squares
- The mean of entries made with the "Σ+" key
- The standard deviation of entries with the "Σ+" key

Automatically convert:
- The decimal angle in any of the angular modes in the display to degrees/minutes/seconds
- The degrees/minutes/seconds angle in the display to a decimal angle
- Polar coordinates to rectangular coordinates
- Rectangular coordinates to polar coordinates
- Centimeters to inches
  Inches to centimeters
- Kilograms to pounds
  Pounds to kilograms
- Liters to gallons
  Gallons to liters

And the HP-45 will also:
- Simultaneously accumulate two sets of entries for statistical and vector calculations
- Allow for deletion of erroneous entries
- Recall the last argument of a calculation to check for accuracy
- Display the constant Pi at the touch of a key
- Permit selective data storage and retrieval in up to 9 registers
- Operate in any of three trigonometric modes—degrees, radians or grads
- Perform register arithmetic
- Perform vector arithmetic
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Actual size

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Allen-Bradley
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Circle 28 on reader service card

EC50

Electronics newsletter

Intel trots out its 4,096-bit RAM

The long-awaited 4,096-bit n-channel random-access memory by Intel Corp. has made its debut. Though the device is not first in the 4k RAM sweepstakes at present [*Electronics,* July 5, p. 25], Intel's memory components marketing manager, A.C. (Mike) Markkula, **contends it will win because it has the smallest chip size**—137 by 167 mils—**and can be mass-produced at lower cost** than those from TI, Mostek, and Microsystems International. The introductory price is $64 in 100-up lots at distributors, but Markkula predicts the price in high volume eventually will drop to 0.1 cent a bit, or $4 a unit.

Despite n-channel processing and high-voltage operation, **the 2107 is slow compared with 1k RAMs.** access time is 600 nanoseconds, read cycle time 950 ns, write cycle 1,500 ns and read-modify-write 1,750 ns power dissipation is relatively low, though—typically 0.4 milliwatt in a power-down mode without refresh, 27 mW on standby with 10% refresh duty cycle, and 264 mW in full operation (maximums are 3.8, 39, and 354 mW, respectively). Power supplies are +12, +5, -5 volts, and ground. The RAM is TTL-compatible and uses a single clock. All decoding is done on the chip and read operations are nondestructive.

Motorola quads driver-receivers

Motorola will soon introduce the first quad twisted-pair line drivers and receivers on the market. The company, which has had EIA modem driver-receivers (MC1488-89) for over two years, **is putting the equivalent of two of the popular 75107, 75108, and 75110 dual units in single 16-pin packages.** The MC3450, similar to the 107 receiver, will have tristate like the strobe National dual LM163 recently introduced. The MC3452 receiver will have open collector output like the 108, and the MC3453 will be a 12-milliampere driver. The Motorola quads have single rather than dual inputs because of package pin limitations. Price will be about 1½ times that of the duals.

Finns buy AIL landing system

AIL's microwave scanning-beam landing system continues to do well in Northern Europe, **even as the company refuses to bid on the FAA's request for an interim microwave landing system** (see p. 42). Fifteen airborne receivers, four ground stations, and a test set have been sold to Sweden's Saab-Scania, the aircraft manufacturer, for new Draaken fighters bought by the Finnish Air Force.

The system is the Tactical Instrument Landing System (TILS) ordered more than three years ago from Cutler-Hammer's AIL division in Deer Park, N.Y., for the Swedish Air Force's Viggen short-takeoff-and-landing fighter. **In addition, field trials are beginning this week in Norway of Co-Scan, the commercial version of TILS.**

Corning realigns European operation

Corning Glass Works, whose sales in Western Europe now run some $200 million a year, plans to tighten up its network of plants and sales companies in the area. **For starters, the company earlier this month put its passive-components business under the wing of a headquarters company called Corning Electronics Europe.** Based in Paris, it will manage joint efforts in marketing, product development, and procurement for Sovcor in France, Electrosil in Great Britain, and Sovcor's sales subsid-

iary in West Germany. The group this year expects sales will be around $20 million; its main products are film resistors, professional-grade capacitors, potentiometers, and hybrid circuits. **Corning's semiconductor affiliate, Signetics, will not join the group effort at the moment,** mainly for legal reasons.

Near-field antenna measurement eyed

Near-field antenna pattern measurements, a concept pioneered a decade ago by the National Bureau of Standards at its Boulder, Colo., Laboratories, may finally be finding acceptance. And as is often true in accepting new concepts, economics is the apparent impetus: **Two large aerospace firms are considering the technique to avoid building new anechoic chambers for antenna measurements on new satellites and other spacecraft.**

The technique uses many measurements made by probes within a few wavelengths of an antenna, and a computer generates a pattern from this data. A 6-by-6-foot frame with probes every half-wavelength is typically required. Near-field measurement, most useful in the low-gigahertz range, **requires sophisticated fast fourier transform algorithms developed only in 1965,** which is why the technique has become practical only in the last few years. There are small correlation problems with traditional measurements, but a source at NBS says, "We think the problems are in their measurements."

Honeywell poised for Moscow opening

Honeywell Inc. may well be the next big U.S. company to open a Moscow office, **while continuing a determined drive to boost its sales base in the USSR.** It would join 10 U.S. firms accredited to Moscow since last summer, including GE and Hewlett-Packard [Electronics, July 5, p. 25].

Over the past 10 years, Honeywell has sold 52 complete computer-control systems to the Soviets, through its French affiliate, Honeywell-Bull, including those for the Fiat-built auto plant in Togliatti and a state banking network in Leningrad. Now Honeywell is **bidding to supply computer, instrumentation, and control equipment for the huge Kama River truck project and the North Star natural gas project** in Western Siberia being proposed by Tenneco Inc., Brown and Root, and Texas Eastern Transmission. Honeywell would equip pipelines, pumping stations and other parts of the latter project.

Memorex quitting mainframe business

Memorex Corp. is dropping out of the computer mainframe market, negotiating sale of a controlling interest to the Singer Co. and offering its creditors stock in an effort to climb out of a "negative net worth" hole. **Memorex went deeply into debt to bring out the MRX/40 and MRX/50 computers last year, then found itself unable to borrow all it needed for full operation in 1973.** Singer would pay $15 million for equity securities, plus a majority vote and the right to obtain a majority of Memorex stock.

If approved, the Singer deal would pave the way for conversion of part of the Memorex debt to preferred stock by the Bank of America and other creditors. Though the bank balked at lending Memorex the $79 million it needed for 1973—after previously advancing some $130 million in credits—the bank has been providing Memorex with enough cash to keep going.

state-of-the-art zeners

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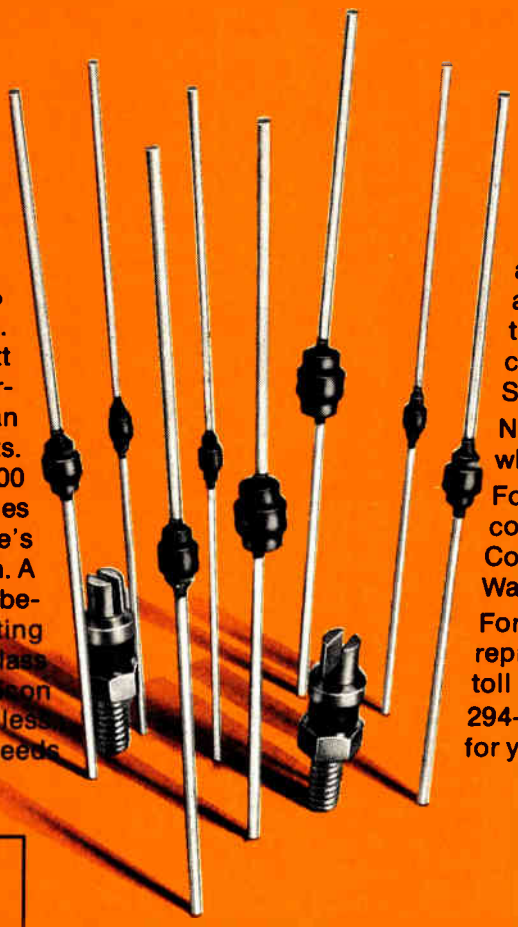

Whatever your needs in hi-rel and military zeners from 1 watt up, Unitrode will give you more. 10 watt zeners from Unitrode will give you 600% higher surge protection than conventional 10 watt types—35% higher than ordinary 50 watt types. And Unitrode 1.5 watt, 3 watt, 5 watt and 6 watt devices provide proportionally higher surge capabilities than their conventional counterparts. Some series are available up to 400 volts. These unmatched capabilities are achieved through Unitrode's unique fused-in-glass construction. A silicon wafer is bonded directly between the terminal pins, eliminating the whisker. A sleeve of hard glass is then fused to the exposed silicon surface resulting in a voidless monolithic structure that exceeds the environmental requirements of MIL-S-19500. The 1.5 watt IN4461 series is available as JAN and JANTX devices to MIL-S-19500/406 and the 5 watt IN4954 series is available as JAN and JANTX devices to MIL-S-19500/356. And Unitrode can really service these specs. Shipment is from inventory.

Now that you know you don't have to, why settle for less than the best?

For fast action, call Sales Engineering, collect (617) 926-0404. Unitrode Corporation, Dept.12Y, 580 Pleasant St., Watertown, Mass. 02172.

For the name of your local Unitrode representative, dial (800) 645-9200 toll free or in New York State (516) 294-0990 collect. Check listing below for your nearest Unitrode distributor.

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See EEM Section 4800 and EBG Semiconductors Section for more complete product listing.

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SOLVE YOUR CIRCUIT DESIGN PROBLEMS WITH VERSATILE AlSiMag® BRAND CERAMICS

TO GET RID OF HEAT

Substrates of AlSiMag® 794 ceramic conduct heat about like the metal aluminum. This remarkable thermal conductivity plus its excellent electrical insulation characteristics and ability to accept metallization have solved many problems of how to dissipate heat from electronic circuits. Bulletin 724 on request. Phone 615/265-3411. Telex 558432.

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TO MATCH THERMAL EXPANSION OF GLASS

Where a hermetic seal to glass is needed, AlSiMag® 842 ceramic can solve your problem. Its thermal expansion closely matches that of the most frequently used glass and forms a reliable hermetic seal. Substrates can be made to the dimensional accuracy you require and with metallization, holes, slots, or depressions as needed. Phone 615/265-3411. Telex 558432.

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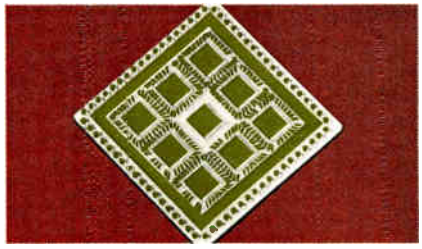

TO SAVE SPACE

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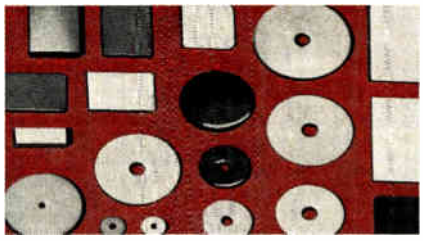

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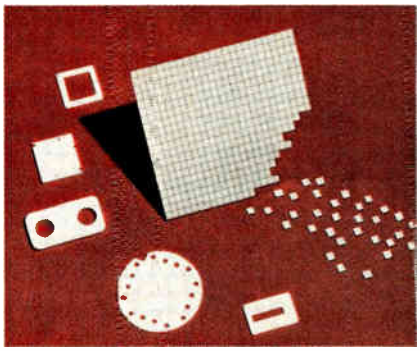

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Prevention years away as computer crime increases

Conference points out that many regard it a challenge, not unethical, to crack codes and gain illegal data entry

The outlook for the prevention of crimes against computers is not good. That gloomy prospect was envisioned last month at a Stanford Research Institute seminar despite a drop in the number of cases reported. While vandalism has been curtailed by the restoration of peace to America's college campuses and better protection of computers, other types of crimes have increased the magnitude of losses.

Among the points made during the discussion by some 50 computer system planners, managers, consultants, lawyers and criminologists were:

- The reduction in reported cases is no proof the crime wave has subsided. Companies victimized by embezzlers rarely publicize their losses, and, as security measures force embezzlers to become more sophisticated, the embezzlers will probably become greedier and harder to catch.
- It will be at least four or five years and possibly 10 years before systems invulnerable to white-collar crimes can be developed. Meanwhile, rapid increases in numbers of computers will increase the number of potential perpetrators of computer crimes.
- Skilled operators of time-shared systems still penetrate system defenses with little difficulty. Many consider it a challenging game, rather than unethical conduct, to discover access codes, rifle a competitor's software, and in some cases, "crash" the programs. Such activities have not been prosecuted in most states because they have not been made illegal.
- To protect themselves, businesses will have to adopt more stringent access control and auditing procedures. To prevent embezzlement, administrative, programing and operating personnel should be "compartmentalized" to prevent collusion. Collusion has occurred in about a third of financial fraud and theft cases, a much higher proportion than in non-computer cases.

Call it abuse. The seminar, believed to be the first conference on computer crime since 1971, was organized by Donn B. Parker, of SRI. Parker wanted suggestions of preventative methods before completing a study of computer abuse for the National Science Foundation. The study, which began in April, is based on a file of 149 cases of computer abuse that Parker has collected during the past three years (Parker prefers the term "abuse" rather than "crime" because many of the reported cases could not be prosecuted).

To date, Parker has documented 54 of the 149 cases. He hopes to develop a "computer threat" model by classifying the *modus operandi* of miscreants. The model would be used to develop a secure system model and eventually a secure system. It will be at least four or five years, SRI engineers estimate, before a secure system exists.

Parker's statistics indicate that the average financial crime with computers involves a loss of about $1 million compared with about $100,000 for conventional embezzlements. And, he pointed out, the crimes are typically discovered by accident rather than by audits. For example, a bank teller in New York was caught when a police raid on a bookie joint revealed he had been placing large bets. He was charged with using his computer terminal to embezzle $1,500,000 over five years.

Parker predicts that computers will cause the total number of white-collar crimes to drop but that the criminals will steal more to justify the difficulty of finding "windows" in security measures. Once a window is found, a "million thefts a second" become possible. He also sees a trend toward unauthorized use of credit rather than thefts of money. Because credit can be transferred into an account, used, and then transferred out in microseconds, such maneuvers will be very difficult to detect.

Time-shared target. Unauthorized use of time-shared computers is commonplace and rarely prevented by law. In a review of computer law, Susan Nycum of the Stanford University Law School pointed out that programs are protected by trade-

secret and property laws in only a few states. Copying programs via phone lines or filching "free time" after access codes have been breached are actions usually not prosecuted because it is hard to convince judges that a property loss occurred. The only effective defense, the conferees agreed, is to cut off the phone lines and refuse to share programs—procedures that are generally impossible to put into effect today.

A group from Mitre Corp. reported that Mitre is researching methods of preventing such maneuvers from being used in military computers. Mitre has spent five years developing a mathematical model of an access control that would concentrate system security in a single, inviolate "kernel" of secure software and hardware. It would detect unauthorized access and attempts to upgrade an operator's security classification through software manipulation. However, development of an operating system is expected to take five years. □

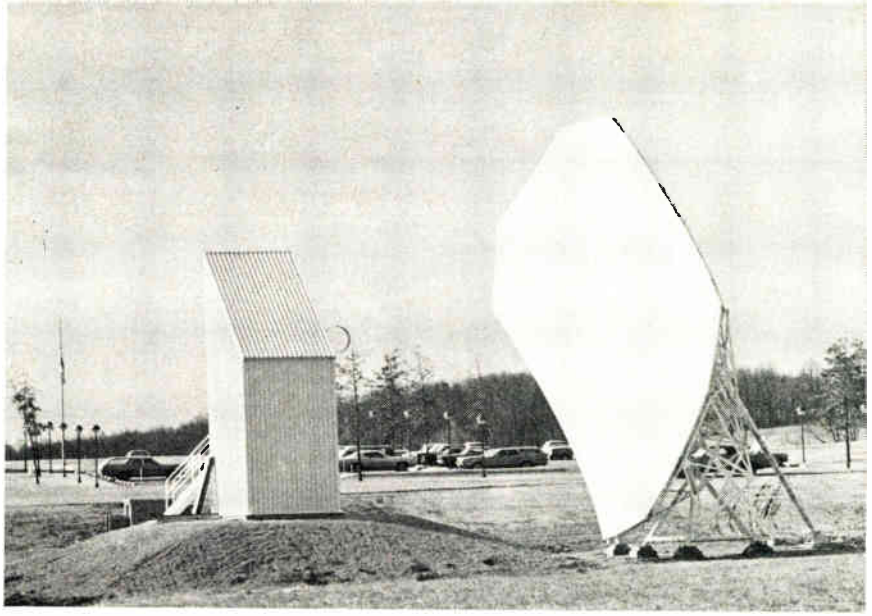
Communications

Comsat wants small earth terminals

Large manned ground stations with steerable dish antennas are fine for heavy traffic over the international satellite networks, but they are too expensive to build and maintain for smaller domestic and regional applications. By turning to solid-state components, engineers at the Communications Satellite Corp. Laboratories, Clarksburg, Md., have designed a smaller automated station to cut the complexity and manpower costs. The modular design of the station enables small countries to afford it [see p. 69].

Called the Reliable Earth Terminal (RET), the station is designed to carry analog and digital communications over as many as 12 channels while under the direct control of a remote manned control center, which could direct from 10 to 100 similar RETs. The design goals for the prototype system were:

- A seven-year lifetime.
- Switching, sequencing, and supervisory functions to operate automatically from a remote center.
- Modularity.
- Fail-soft operation so that the parametric and intermediate-frequency amplifiers continue to pass signals at reduced gain, should one stage fail.
- Transmission parameters and quality high enough to meet proposed U.S. domestic system and international network standards.



Cost conscious. Comsat Labs' automated earth station makes maximum use of solid-state components to cut costs to about a third of present stations.

Louis Pollack, head of Comsat Labs' technology division, estimates that an eight-channel RET would cost about $1 million, about one-third the cost of current terminals.

What was done. "The trouble with current earth terminals is that they're designed as a response to an RFQ. They're not designed scientifically," comments William K. Sones, senior staff scientist with Comsat Labs' Technology division. Comsat engineers focused on several key areas to improve existing designs. They replaced cryogenically cooled parametric amplifiers with uncooled fail-soft ones and high-powered water-cooled amps with multiple low-powered, air-cooled power amps. They relocated the telephone multiplexing equipment and also substituted a fixed torus antenna with a movable-feed combination for the world-coverage steerable-dish antenna.

The result is a much smaller station. There is only one vacuum tube in each transmitting chain—a high-gain 400-watt traveling-wave tube driven by a solid-state parametric up-converter. "It's the only tube in the terminal; everything else is solid state," Sones says. Microwave ICs are used extensively.

By contrast, present terminals use one big high-power amp to drive the multiple carrier channels. This is clearly inefficient, Sones says, because "you're putting in 90 kilowatts of power and only getting 2 to 3 kw out." That, plus a backup amplifier and a big $25,000 tube increase costs. Instead, Comsat gave each carrier channel its own high-power amp. "The big problem was how to combine them" into the single channel that feeds the antenna, Sones says, but that was solved by using dual-mode eliptical filters.

The receiver design got considerable attention, too. For example, if one stage of the uncooled parametric amplifier fails, it still functions at reduced gain. □

Components

SAM-D connector pact sets precedents

The airborne guidance system of the Army's SAM-D air defense missile requires about 90 different connectors, all unique, all of which must be developed from scratch. Tradition-

ally, as many as 40 to 50 subcontractors may make connectors for such a system, but this time around the Raytheon Co.'s Missile Systems division, Bedford, Mass., SAM-D prime contractor, decided to solicit bids on only two contracts, one for rf and one for multi-pin connectors.

The winning bids on both of them came from Amphenol Components Group's SAMS division in Chatsworth, Calif.—the first time, Raytheon believes, that a connector contract for such a program has been let to a single company. Why the decision to go with one subcontractor? William Thibodeau, project engineer, says that connectors form at least 10% of a typical system, but have traditionally gotten short shrift in system planning.

Fragmented. When contracts are scattered among many companies, the task of coordinating them all can be formidable. Not all connectors may be compatible with the system, and it can be difficult to control costs.

The fact that all subcontracting management is under one roof is one bonus of the arrangement. Terence Bracken, project engineer at Raytheon notes, "We have the attention of management and . . . we get consideration that permits us to develop in a timely manner; this is difficult if you deal with a multiplicity of houses." Once production starts, it keeps on rolling, and if new connectors are needed, they don't have to be put up for bid. The contract with Amphenol also calls for test connectors and equipment, usually an afterthought in most contracts, the Raytheon engineers say.

Amphenol won the contract with a bid of $5 million. Bracken estimates that, handled traditionally, the cost could easily have been twice as much. Part of the savings come from reduced engineering costs—for instance, Amphenol is doing one documentation package for the final procurement, instead of Raytheon's doing the same job, and for several suppliers. Dealing with one company also cuts down management overhead at Raytheon; Thibodeau notes that Raytheon has quality assurance and reliability people, and others responsible for the connectors, and "trying to impress their needs on 50 companies can be hard."

A drawback to having only one source is that a problem can affect the whole operation. On the other hand, Thibodeau points out, "you can solve [the problem] once and it it solved for the whole system."

Cutting costs. Besides engineering and management savings, Amphenol also offered a connector system that was more cost-effective, says Thibodeau, and considerably smaller than those generally used in military systems.

The rf connectors will be supplied by the Amphenol RF division, Danbury, Conn., and the multi-pin connectors by the Amphenol Connector division, Broadview, Ill.

A key to the cost effectiveness of the multi-pin connectors is the use of interchangeable piece parts. Each front insert and rear retention disk pair can be used with a variety of pin styles.

Amphenol's choice of Astrel P-360 as the molding material is another plus. This polarylsulfane produced by 3M can retain the clip without a retention clip. Because its strength is twice that of conventional materials, Astrel P-360 requires increased molding pressure, but its cure time is considerably shorter so that more devices can be made from fewer molds, lowering tooling costs.

Amphenol also broke precedent by using machined instead of molded parts in the breadboard stage. This allowed parts design to be changed inexpensively, and the first shots of the mold were consistently better than usual as a result.

The arrangement may well set a

Instrument hastens identification of disease-carrying micro-organisms

Botulism—the bacteria-caused malady that periodically causes a widespread scare and a recall of canned foods—could be combatted earlier than is now possible with the help of an electronic instrument developed by Applied Magnetics Corp., Santa Barbara, Calif.

The Bactometer 100 can quickly identify the micro-organisms that cause food spoilage and possible poisoning. It provides results automatically in an hour or less compared with the lengthier conventional process of growing cultures and turning them over to skilled technicians for analysis under a microscope.

Similar equipment is just now being tested in clinical laboratories for such maladies as gonorrhea, now detected by similar culture growth. Applied Magnetics, however, is marketing its instrument only in the food processing field through two food equipment divisions: Key Equipment Co., Milton-Freewater, Ore., and Electro Sonic Control, Manteca, Calif. It will be priced at $7,500 to $15,000 when it becomes available next summer.

Although the new test instrument also works on cultures, its high sensitivity permits much faster results than optical methods. It's basically a sophisticated impedance bridge that exploits modern circuit techniques. In use, two samples are prepared, one with the test material in a liquid culture and the other a reference in a sterile medium. The two cultures are subjected to favorable growing conditions, and their impedances plotted on an integral strip chart recorder. If growth takes place in the test sample, indicating contamination, its impedance drops.

Identity. Specific bacteria or other micro-organisms have characteristic growth-curve "fingerprints"; still more assured identification is possible if a medium favorable to the suspected contamination is chosen. The amount of micro-organisms is also indicated.

The bactometer operates automatically once test samples are inserted, and no special operating skills are required. A number of samples can be processed simultaneously.

pattern for future contracts. "Control of vendor selection is taken out of the engineers' hands and becomes a management function," Raytheon SAM-D project engineer Thibodeau says. □

Commercial electronics

Computerized scale weighs railroad cars

The only thing that moves in an electronic weighing system recently installed in Alexandria, Va., railroad hump yards is the freight car being weighed. The computerized scale, which railroad officials say increases accuracy and efficiency, weighs single cars traveling about 10 miles per hour with a high accuracy— within 50 pounds for a 176,000-lb car, according to recent tests conducted by the operating railroad.

Developed by Sands Measurement Corp., Dallas, Texas, the scale uses a fixed-program minicomputer "of our own design" which takes analog inputs from track load cells or weight sensors and processes them digitally to derive the weight, says president S.H. Raskin.

Humped. National Bureau of Standards test car approaches 20-ft. section of track where electronic scale weighs it in Alexandria, Va., railroad hump yard.

But how does the scale differentiate the extraneous forces, such as those from out-of-round wheels or sloshing liquid loads, from the weight? "That's what took us 13 years and $3 million to find out," he answers.

Raskin says his scale uses the "bending-beam principle" instead of the "vertical support" approach so that the scale only measures the vertical weight source and not the horizontal. He explains that the proprietary "electromechanical system" measures the bending of the steel structure that supports the rails and translates that weight force into voltage "with all the jiggling and bouncing and perturbation transients, computes the accurate weight and throws away the garbage."

Simple. The Sands scale, a maintenance-free, self-contained, welded structure, needs no below-ground concrete and can be installed in a few hours. Conventional scales require extensive and costly construction and about 105 feet of track. The new scale uses four strain-gauge sensors on each of two parallel 20-ft rail sections and weighs each rail independently, but simultaneously, to cope with cars with off-center loads, Raskin says.

Thus, the scale "weighs each end of the moving car, and the computer totals the weights to get the car's total," he says. As the car moves over the scale, a worker punches the car number and empty weight into a keyboard. After the computer derives the weight, it transfers the result to a remote terminal, which prints out a ticket listing the date, time, and car number, plus gross, empty, and net weights.

The market should be good for the new technology, Raskin says, because there are more than 6,000 railroad scales in the U.S., many of them 40 years old. Sands builds three types of electronic scales—static, uncoupled moving-car, and coupled moving-train systems—costing from $35,000 to $150,000 each. Sands has sold dozens of railroad scales, but the Virginia model was the first in its single-moving-car line;

From railroad cars to diapers

S.H. Raskin of Sands Measurement Corp. calls his scales "force-measurement devices" and says they can count as well as weigh using the "bending-beam principle." Sands has sold its devices to a linen service to count piles of diapers speedily. And in other applications they're used to tally milk containers by weight and to count stacks of bank notes.

For more conventional uses, a major drug company weighs drugs in 2-gram increments up to 25 kilograms, and a dairy uses a "sloshing-kilogram" version that weighs milk containers as they move along a filling line to prevent overfilling. For post offices, the scale not only replaces four conventional units but weighs accurately to half the weight of a postage stamp, or 50 millionths of a pound. General Motors Corp. uses one in an engine foundry, and Sands has sold 60 "to a major airline" as part of a computerized baggage system. The same computer is used in all the scales.

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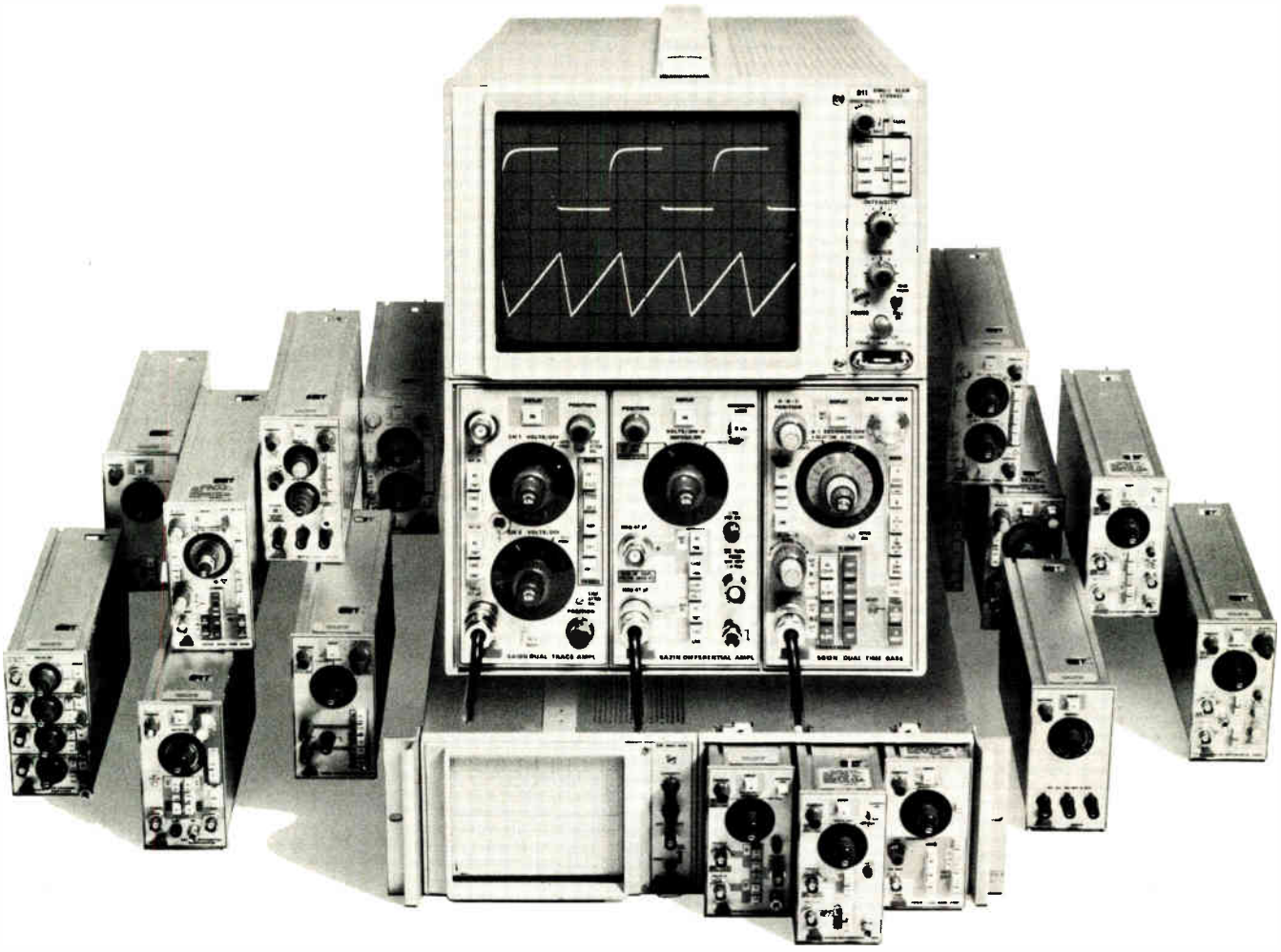


For a demonstration circle 36 on reader service card

Circle 37 on reader service card

Richmond, Fredericksburg & Potomac Railroad officials express delight with the scale, which weighs about 1,500 cars a day.

Because the scale can differentiate flat wheels and skewed axles, Raskin says, he can add a safety-inspection module onto it. Moreover, automatic car-identification systems, which log car numbers by scanning colored bar codes, also could be incorporated, he adds. □

Production

GaAs crystal grower promises price cuts

While interest in gallium arsenide has been growing, those who want to use it have sometimes been driven to the extreme of jury-rigging GaAs crystal growers from silicon crystal growers—not always a satisfactory method of production, because, among other things, GaAs production requires a pressure of 20–30 psi in the furnace, while silicon can be grown at atmospheric pressure. Now Varian Associates, a major builder of silicon crystal growers, has a commercial GaAs crystal grower, the Varian/NRC model 2835.

The 2835 employs a Czochralski-type crystal-growing furnace like that used for growing silicon, in which the crystal is pulled vertically out of the furnace. And, thanks to its much larger GaAs output, says Dennis K. Williams, product manager for advanced material equipment at the Vacuum division's NRC operation in Lexington, Mass., users of the system can sell the material for $3 to $4 a gram, or half to a quarter the usual cost.

"With the Czochralski method, it is easy to control parameters like pull rate and diameter of the crystal, and you can start over again if you make a mistake," he explains. In contrast, the Bridgman technique now used to produce most GaAs embodies a horizontal process—the melt is moved in a boat from a hot zone through a thermal gradient and slowly frozen. "This is a long, slow process," Williams notes, "and you don't have too great control over it."

A complete Varian system includes a power supply, furnace tank and growing chamber, graphite hot zone, isolation valve, crucible, seed-lift rotation mechanism, and all electrical controls.

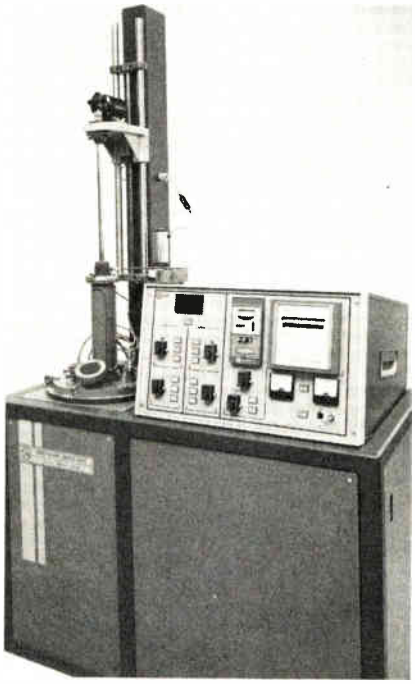
Already at work. The first of the $25,000 to $30,000 systems are in operation, and Williams claims that "from what people have told us, on a machine-for-machine basis, the Czochralski method outproduces the Bridgman method by a factor of two or three." Crystal size can range up to 2.25 inches in diameter and 16 inches long, and production speed is variable from 0.2 to 2 inches per hour.

The 2835 now has a hot zone 5 inches in diameter, but within 12 to 18 months, Williams says the company expects demand to be great enough to call for furnaces 8 inches in diameter, such as are used in silicon crystal growers.

"The demand at this point is just astounding for GaAs," Williams says, likening it to the state of the silicon business 10 years ago. He expects demand to grow at an exponential rate for a while. He points to a paper by J.F. Wenkus of Arthur D. Little Inc., that puts 1973 sales of GaAs at $23 million and 1975 sales at $35 million.

One of the major uses of GaAs is in light-emitting diodes, and Williams says that Czochralski-grown GaAs accepts the epitaxial layer applied to LEDs better than Bridgman-grown GaAs. "This is related to dislocation density," he says, "—the greater the density, the better." □

GaAs grower. Varian's Czochralski unit.



Military electronics

Awards resurface Project Sanguine

Whatever became of Project Sanguine? With the award of three competitive contracts for design of the extremely low-frequency system for secure communications with the U. S. fleet ballistic-missile submarine force around the world, the Naval Electronic Systems Command has given one more signal that it has not given up on the once-controversial project [*Electronics*, Nov. 24, 1969, p. 48].

But the course set for Sanguine by Navelex is clearly a more cautious one, reflecting perhaps a certain maturity following its 1969 flap with a small but vocal group of environmentalists. They protested to Congress the Navy's selection of the bedrock under Wisconsin's Chequamegon National Forest as a site for burying its Sanguine communications grid. After Sanguine's opponents claimed the proposed system measuring 150 miles on a side would wreck the forest primeval, causing radiation pollution that would damage animal and plant life, the Navy went back to the drawing board.

After more than three years and a variety of contract studies by groups ranging from MIT's Lincoln Laboratory to the National Academy of Sciences, the American Institute of Biological Sciences, plus other site surveys, Navelex found it could sharply reduce the system's cost and

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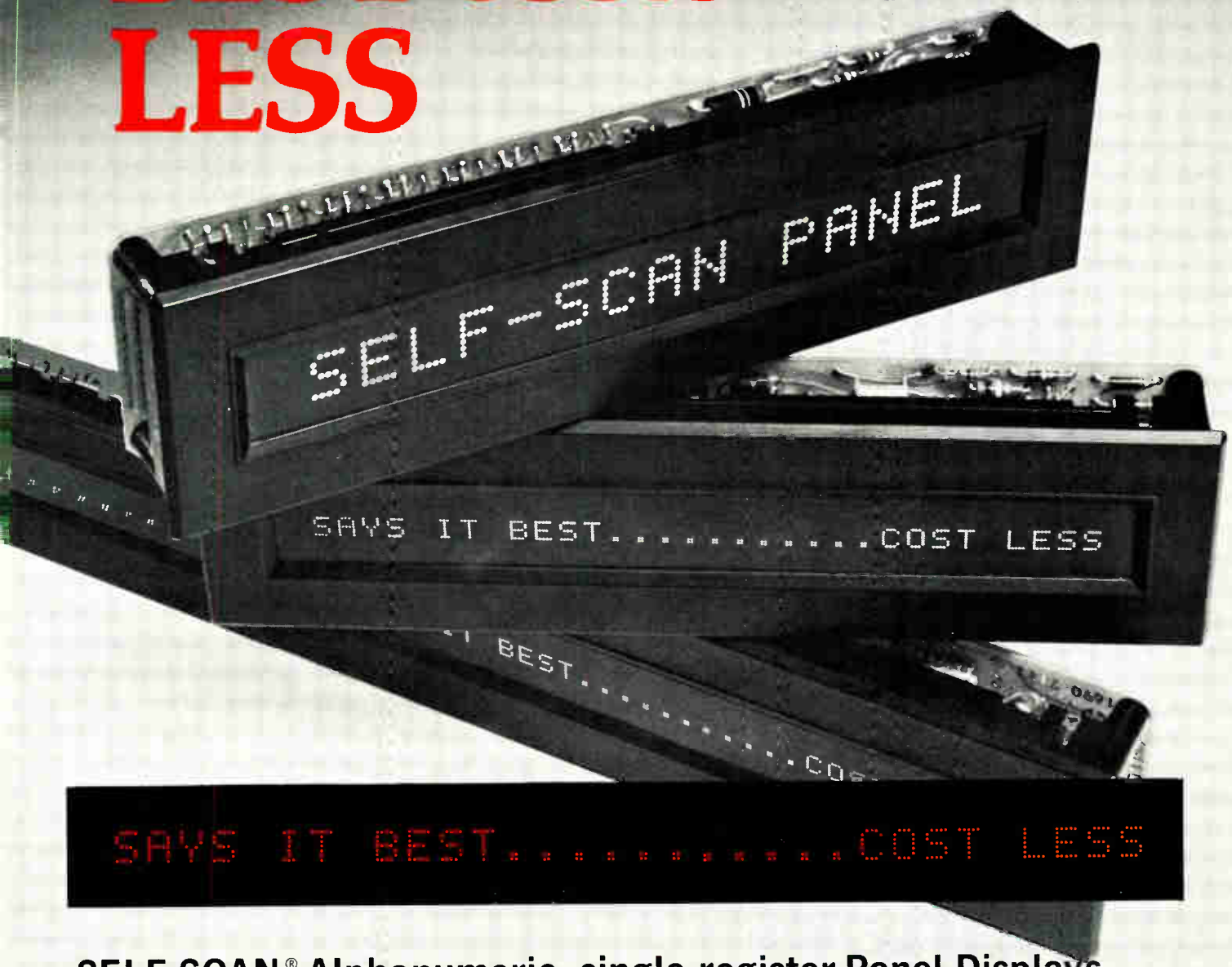

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size, cut its power requirements from 300 amperes to 150 and locate it in a variety of places that also featured nonconductive rock formations (see p. 79).

Awards. Following completion of the $3 million "concept validation" design proposals by GTE Sylvania Electric Products Inc., Waltham, Mass., RCA Communications Systems, Camden, N.J., and TRW Systems Group, Redondo Beach, Calif., Navelex expects to award one, possibly two, full-scale development contracts in the spring or summer of 1974. Full-scale development, explains Navelex carefully, will not mean pushing ahead with an all-up system. Instead, it will cover "full-scale design, prototyping of some key components, and possibly some work on developing" modularity.

That two-year effort makes a production decision on Sanguine impossible before the end of 1976. And, adds the Navy, "there will be no significant adverse environmental impact" during the development phase in which prototype hardware "will be installed and tested at the existing Wisconsin test facility or other sites as appropriate."

In its ongoing reevaluation of Sanguine, the Navy has determined an effective system can be built using 100 times less radiated power than originally proposed. In terms of costs, estimates are now running "between $100 million and $400 million depending on the capability the Navy wants to buy." These figures compare with projections of $800 million up to $1.2 billion in years past. □

Solar energy

Solar cell prices dropping, but broad terrestrial use awaits mass production

The price of silicon solar cells is beginning to float downward, a prerequisite for more widespread terrestrial applications of the power-collecting devices. At the same time, performance of both silicon and cadmium-sulphide solar cells continues to climb as technologies improve. But mass applications await volume production. That was the consensus at the International Solar Energy Conference earlier this month in Paris.

Up to now, the solar-cell market has been small and limited to space applications [*Electronics*, May 22, 1972, p. 67]. Just two companies share the $5 million worth of business of the whole U.S. space program, points out Joseph Lindmayer, director of the Comsat Physics Laboratory. They are the Centralab division of Globe Union Inc. and Heliotek division of Textron Inc. But late last month Exxon Enterprises Inc., a subsidiary of the Exxon Corp., agreed to back the Solar Power Corp. Solar Power, set up in April, will manufacture and market a silicon cell designed by Exxon for such earthbound applications as navigation aids, standby power systems and power for remote communications and environment monitoring equipment. Solar Power president Elliot Berman claims the basic 1.5-watt module is made up of five cells and sells for $30 in quantities of more than 1,000. For space applications, by contrast, peak wattage costs between $100 and $200.

At work. Solar Power's arrays are already in use on offshore gas production platforms to power navigation signals, in the Yellowstone National Park to power radio repeaters, and on railroad systems to power microwave signals for train traffic control.

Spurred by the domestic space program, the French, too, have moved into ground uses for photovoltaic power. RTC—La Radiotechnique-Compelec is aiming primarily at developing countries, where conventional electric power systems are not always on tap. Applications developed so far include arrays to drive a 33-watt television set, a 12-watt telecommunications center, and a 50-watt air navigation radio beacon.

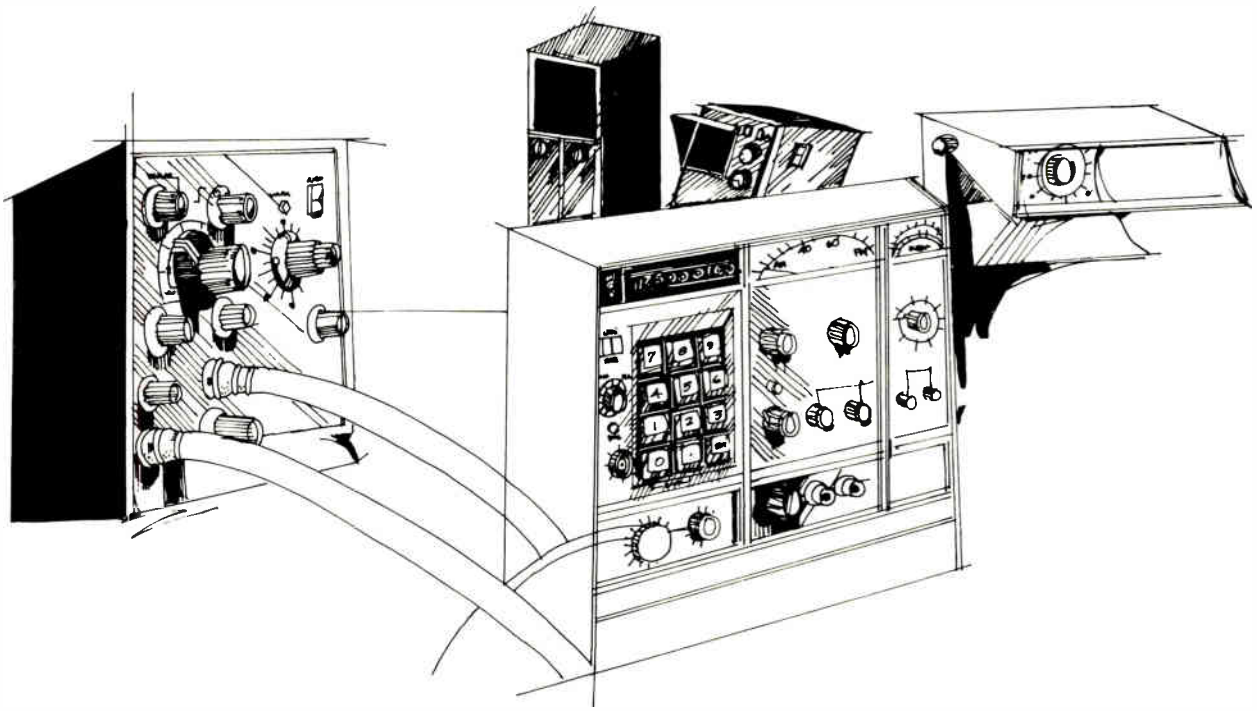
At first glance, the French cells seem to be about twice as expensive per watt as the Solar Power products. The RTC modules comprise 64 cells, 40 millimeters in diameter, mounted on an epoxy board to give total output of 8 watts. Their price is $310 in 1,000 quantities. But the 8-watt units have lower interconnection costs for large arrays and that makes up much—if not all—of the difference.

Prices prohibitive. For large-scale power plants, today's prices are out of sight. The U.S. Solar Energy Panel concluded some months ago that solar energy could provide more than 20% of the electrical power needs of the U.S. over the next 30 years, provided adequate research and development funds became available. This year, for starters, the National Science Foundation has $12 million to work with. Panel members at the Paris Conference pointed out that solar cell arrays are still two or three orders of magnitude too costly for large-scale ground applications. If current U.S. output of about 500 square meters of solar array were to be switched to high-volume automated processes, say the experts, cost factors would come down by a factor of 20 or 30. Even then, a 1,000-megawatt photovoltaic power plant would cost about $70,000 per installed kilowatt. And the plant would cover no less than 50 square kilometers.

Some think the answer is new materials. Dieter Bonnet of the Battelle Memorial Institute in Frankfurt points out that silicon has to be a very-high-purity crystal and that makes it too expensive for big installations.

The French feel the same. They are ahead in developing cadmium sulphide as an alternative. The Société Anonyme de Télécommunications reported at the conference that it has resolved the problem of inherent instability in the materials, though they have not yet reached the efficiency levels of

MEET THE MONEY SAVERS



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silicon cells. A figure of around 5% is the present mark, and 7% has been reached in lab tests. Yet the supporters of cadmium technology point out that costs have been driven down still further by the development of a new system of printing the cell grid screen on the cadmium sulphide layer. □

Air traffic control

Two firms quit FAA MLS race in anger

The Federal Aviation Administration has drawn the ire of two competitors for the standard Interim Microwave Landing System (IMLS). Cutler-Hammer Inc.'s AIL division and Texas Instruments have angrily dropped out of the multimillion-dollar competition, charging that the agency's plans were ill-considered and didn't serve the aviation community. Particularly irksome was the FAA's requirement that it must receive license rights to the winner's design for at most $25,000 so that the system could be produced by other manufacturers of air-traffic-control equipment [*Electronics*, June 21, p. 51].

Their walkout leaves Boeing Electronics Manufacturing division of Seattle, Singer-Kearfott of Little Falls, N.J., and Tull Aviation Corp. of Armonk, N.Y., competing for the standard system, which would become eligible for 50% Federal funding under the Airport Development Aid Program. The FAA timetable calls for paper evaluation to be finished by July 17, a week's pause, and then two to three weeks of field trials at the Richmond, Va., airport, with the winner to be selected in September.

In the competition among newcomer Boeing [*Electronics*, July 17, 1972, p. 32], established Singer and tiny Tull, the FAA is expected to give considerable consideration to the cost of the units to airport operators. Speculation is that Boeing, which apparently was able to convert its system to meet the split-site requirement just in time, may have "lowballed" its prices for competitive advantage to around $30,000 for ground units. A Boeing spokesman replied that such practices aren't typical of the company, adding "How does anyone know what prices the FAA has?" The Boeing and Tull systems use airborne convertors, which transform the received microwave signal into low-frequency signals compatible with cockpit hardware in existing instrument landing systems. Singer got a head start in the civil field with its Talar unit for the Air Force.

Plagued. The FAA has had trouble with the IMLS plan almost from the start [*Electronics*, Aug. 28, 1972, p. 29] in trying to find out how to choose one system among competing companies with differing technological approaches. Almost all companies criticized the agency when it devised the present approach, especially the licensing requirement. That could become a sticky issue yet when the winner and the agency sit down to negotiate rights. An executive with one competitor also points out that the Richmond airport is better suited for conventional ILS than MLS systems intended to operate in difficult sites.

AIL, in writing the FAA, said that "because [the RFP] does not represent a careful, considered program of analysis of the needs of the aviation industry for the next five to 10 years, and because it lacks a techni-

NOAA research promises weather, pollution sensors and role for 'lidar'

The use of lasers and "lidar" (laser radar) as weather and pollution sensors for the advanced automated weather stations of the future is being evaluated under a National Oceanic and Atmospheric Administration program that promises to produce a new class of electronic hardware. Based on five years' laboratory work, NOAA scientists predict that the monochromatic precision of laser and lidar devices will give meteorologists and ecologists new weapons with which to fight weather and pollution adversities. A new program for the U.S. Weather Service is expected to lead to prototype hardware development.

Right now, according to Vernon Derr, director of the wave propagation laboratory's atmospheric spectroscopy program, automated systems can measure only temperature, humidity, pressure, the speed and direction of wind, and precipitation. Laser or lidar techniques would extend this to the constituent gases, aerosols and particles in clouds, dust, fog and polluted air. Lidar (light detection and ranging) uses a laser that sends out discrete pulses of light and allows observation of how the light is affected by atmospheric constituents, temperature and motion.

Tuning in. Tunable lasers, for example, would enable scientists to analyze the atmosphere for signatures of such pollutants as carbon dioxide and sulfur oxides. These signatures are the attenuation of the light caused by the molecule's absorption of the corresponding single wavelength of light.

This and other techniques have been used successfully in both field and laboratory, Derr says. With the continuing development of laser technology they can be extended to real operation. However, lidar observations are limited to one kilometer in some uses, he adds, but more powerful lasers should allow measurements up to 20 kilometers, even through local bad weather. Side benefits include deriving the altitude of the observation through timing the return of lidar pulses and wind speeds by doppler measurement.

Derr says that the most important regions are the visible, where "there are good tunable lasers," the ultraviolet, which is "beginning to open up," and the infrared, where CO and CO_2 lasers are maturing. Although initial costs for automated systems would be high, on a large procurement basis the units probably would cost less than the maintenance of manned stations.

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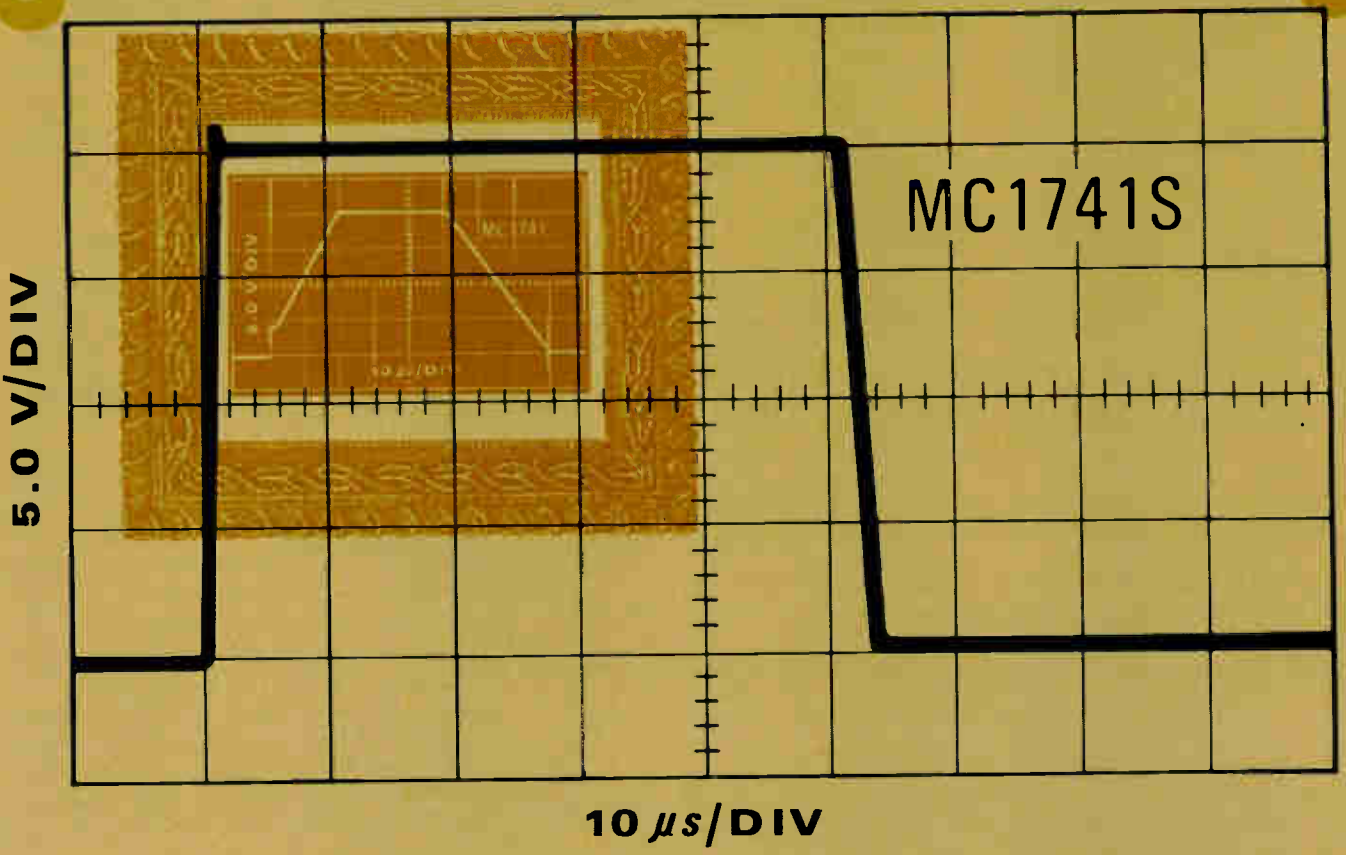

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News briefs

Cartridge Television bankrupt
Cartridge Television Inc., San Jose, Calif., maker of the first and only consumer video player, has filed Chapter 11 bankruptcy. Having exhausted its funds, CTI has established a moratorium with its creditors, and meanwhile, parent company Avco Corp. will write off $48 million of CTI's debt.

The reason, admits CTI vice president and controller Thomas J. Sullivan, was that "we were geared to produce more units than we were selling, and some were not up to standard." CTI also had to recall some defective magnetic tape during the 1972 Christmas rush. CTI plans to look into other markets to revitalize the company, especially the hotel-motel market.

CDC snares AEC award . . .
The Atomic Energy Commission has again named Control Data Corp. to install $28 million worth of computer systems at Brookhaven National Laboratory, Upton, N.Y.; Los Alamos Scientific Laboratory, N.M.; and Lawrence Livermore Radiation Laboratory in California. CDC bid a single 7600 model, plus two of its large-scale Star systems [*Electronics*, Mar. 30, 1970, p. 52]. These same systems had won the same AEC competition earlier, which the commission sought to void following a dispute over penalties to be paid by CDC for late delivery. The new contract calls only for standard penalties contained in any General Services Administration contract. Loser in the competition was Texas Instruments' Advanced Scientific Computer.

. . . and introduces new computer
Control Data Corp. has introduced a new line of small computers for industrial and communications applications. The series 17, priced from about $14,000, is built on the 1784 processor, which has a semiconductor memory with 600 or 900 nanosecond cycle time, and a capacity of up to 65,536 words of 18 bits each. A line of peripherals is also available.

Siemens begins expansion drive
Seeking to expand operations in the United States, Siemens Corp. of America, Iselin, N.J., has acquired Computest Corp., Cherry Hill, N.J., a manufacturer of special computer-based test equipment. Computest's manufacturing facility will be phased into production of products for Siemens, domestic arm of the Siemens Group, West Germany, and will include the computer-based diagnostic system used in Volkswagen automobiles. Moreover, Siemens plans further acquisitions and expansion in components, medical equipment, and telecommunications in the near future.

Pentagon cancels SCAD missile
After an outlay of $67.5 million by the Air Force, the Defense Department has canceled engineering development of the Subsonic Cruise Armed Decoy missile [*Electronics*, July 5, p. 50]. Designed to help strategic bombers reach their targets, SCAD was cut on the ground that cost projections were too high in relation to anticipated performance.

Cancellation of SCAD, which would have upgraded the B-52 bomber force, was viewed by some as advantageous to the B-1 bomber in development by Rockwell International Inc. The substitution of a smaller technology program to preserve SCAD options could aid Philco-Ford Corp., subcontractor for decoy electronics, but would provide little assistance to SCAD missile developer Boeing Co., or the guidance system contractor, Litton Industries Inc.

Mobile radio market to soar by 1982
The mobile radio equipment market will climb from $514 million annually in 1973 to $1.2 billion by 1982, with revenues aggregating $7.5 billion over the 10-year period, reports market research firm Frost & Sullivan Inc., New York. Independent maintenance and servicing will parallel the growth, says the company; a $124 million volume in noncaptive maintenance in 1973 will reach $335 million by 1982, with revenues aggregating $2.2 billion.

cally sound and reasonably comprehensive program of system evaluation, AIL feels that submission of a proposal at this time would be unwarranted." An official with TI, licensee of Thomson-CSF's Sydac system, said that the company objects to the scheduling and the "implications for worldwide licensing" for the winning design. "No one is happy with that RFP," he said. □

Computers

IBM widens MOS use in new systems

Semiconductor memories are making even further inroads into previously all-core territory, with two recent announcements from International Business Machines Corp. The first announcement is of the System 3 model 15, with a main memory of up to 131,072 characters, built with metal-oxide-semiconductor technology. IBM's second announcement covered the enhancement of memory sizes for the System 370 models 115, 125, and 135.

Previous models 6 and 10 of the System 3 use core memories of a maximum of 32,768 characters; both are still in production—the model 10 after four years. The new MOS memory modules are not available for use with the older systems. Other characteristics of the System 3 model 15 are the availability of multiprograming for the first time in this line, up to four IBM 5445 disk storage units with a capacity of 20.48 million characters each (a maximum of two was available on the model 10), an IBM 3410 magnetic tape system, and a fast line printer, the 1403.

The model 15, which can use programing languages familiar to most System 3 users, rents for $3,240 to $7,127 per month—as compared to $2,628 per month for a typical configuration of the model 10.

Semiconductors all. The three models of the System 370 are at the low end of the line. All were origi-

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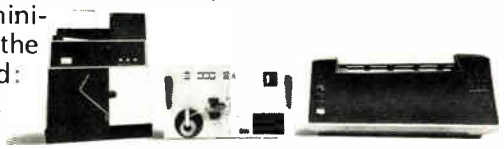

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Dubut. IBM's new System/3 Model 15 has up to 131,072 characters of main MOS memory.

nally announced with semiconductor memories—MOS in the 115 and 125 and bipolar for the 135. All are now using new 2,048-bit MOS chips (the same as used in the System 3/15) or 1,024-bit bipolar chips. The enhancements increase the total memory capacities for the model 115 by 67% (to 163,840 characters), 100% for the model 125 (to 262,144), and 113% for the model 135 (to 524,288). □

Army seeks PEPE for missile defense

Take 288 computers, each able to handle from one to five million instructions per second, and interconnect them with a Control Data Corp. 7600 control computer, and what have you got? The Army calls it a Parallel Element Processing Ensemble, or PEPE, a major step forward in intercontinental missile defense [*Electronics*, July 5, p. 49]. The Advanced Ballistic Missile Defense Agency has ordered its first experimental and test system from System Development Corp., Santa Monica, Calif. The computer system uses 36 processors.

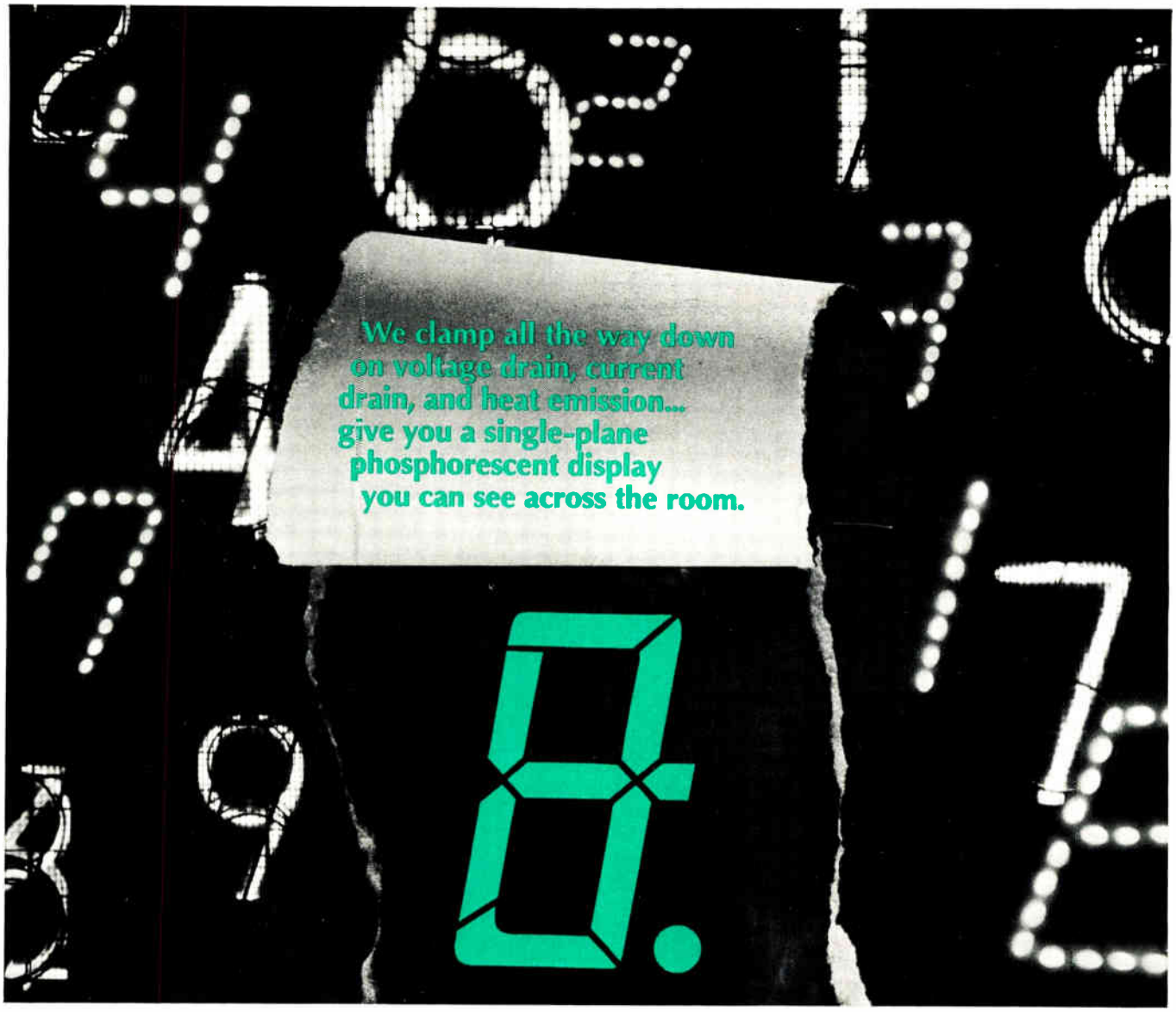
The $9.5 million award calls for installation and test of the system at the ABMDA research center at Huntsville, Ala., over a period of 39 months. More than $5 million of that will go to subcontractor Burroughs Corp. for design and production of the 36 special-purpose machines using MSI technology. Under the cost-plus fixed-fee award to SDC, the work is expected to be completed by July, 1976, including software development and demonstration of the processor's over-all effectiveness within the context of ballistic missile defense. Each of the small Burroughs processors will have a capability approximating that of an IBM 360/65, say SDC project officials at Huntsville.

Concept. The PEPE concept was first proved in 1971 using a brassboard configuration at Bell Laboratories with 16 small, Bell-developed computers under control of an IBM 360/67 [*Electronics*, May 24, 1971, p. 32]. Honeywell Information Systems was also involved, but is no longer participating.

Economy and speed of using small computers for processing data from anti-ballistic missile defense sensors, while simultaneously employing a large, modified commercial machine for ABM command functions, was the rationale for developing the advanced PEPE system.

The future for PEPE "depends on a lot more than just the success of the program," explained one SDC official. "It depends on the success of the SALT talks" and similar political factors. The system is a sophisticated processor for advanced ABM systems beyond the existing Safeguard and Hardsite developments. "If the country decided to go ahead and deploy some of these advanced ballistic defense systems, PEPE is one of the foremost contenders for data processing hardware," he added.

Other approaches to missile defense being considered by ABMDA include "putting more installations in, instead of increasing the data processing power—more radars, more interceptors. Each installation would be small." Other plans include "using multiprocessors of the CDC 7700 variety with a capacity of approximately 20 million instruction per second" compared to PEPE's total capacity, "which is up around 300 million instructions per second, counting the host machine." □



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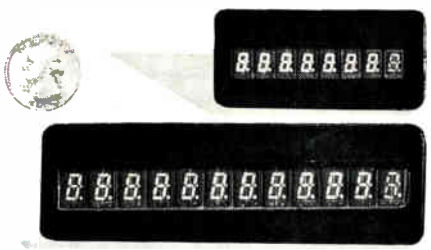

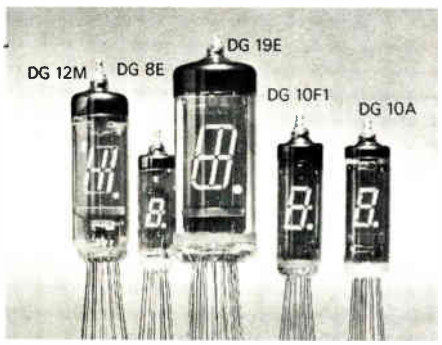

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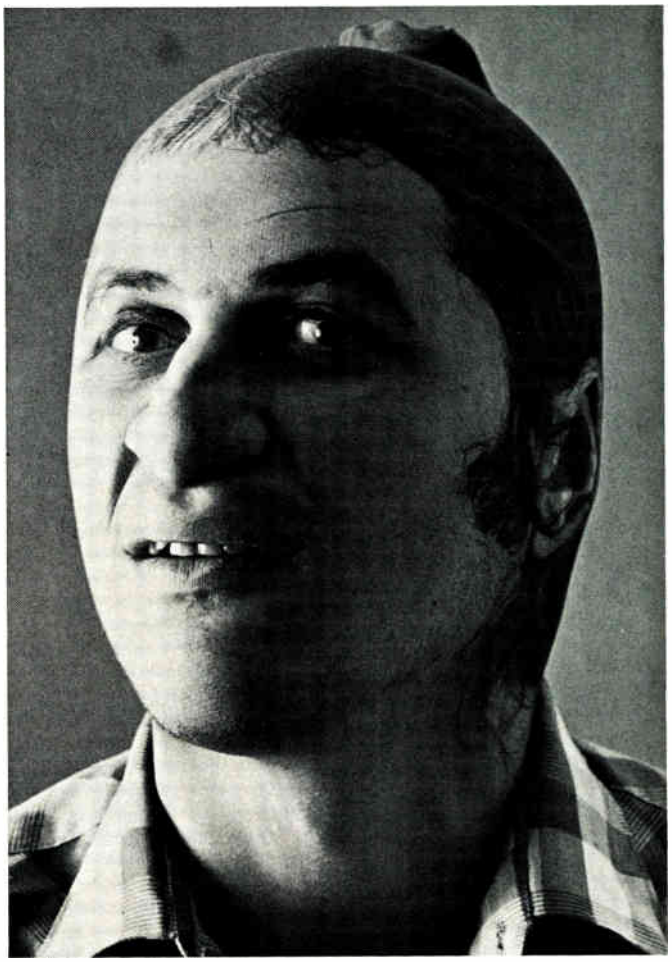

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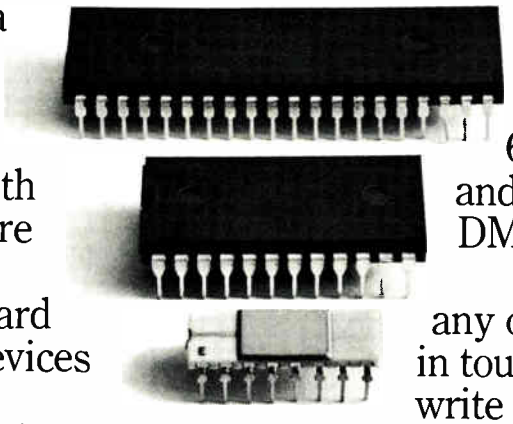

For further information on any of this including how to get in touch with one of our FAE's, write National Semiconductor Corporation, 2900 Semiconductor Dr., Santa Clara, California 95051.

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Washington newsletter

Electronics to share in transit-car market estimated at $8 billion

An estimated $8 billion market for subway and trolley cars—of which **40% would go on electronics, including motors and controls**—is forecast over the next 10 years by Boeing Vertol Co. The estimate is based on such factors as development of new mass transit systems, changing public attitudes, Federal development of model cars, and government funding through transit grants or revenue sharing. Martin Lenow, marketing manager for surface transportation systems, **pegs the total systems cost at over $30 billion, including command and control equipment.** Atlanta, Baltimore, Los Angeles, Minneapolis-St. Paul, and Pittsburgh are among those developing or planning systems. Other companies eyeing the market include LTV, Pullman Standard, Rohr, and Westinghouse. Boeing Vertol is building trolley cars for the Boston and San Francisco municipal transport systems.

Avionics rides general-aviation sales boom

Partially helped by a congressional check on the FAA, sales of new general-aviation aircraft—and new avionics to go in them—will reach **a record high of near $800 million this year,** compared to the 1969 high of $639 million, predicts Edward W. Stimpson, president of the General Aviation Manufacturers Association. **General-aviation avionics usually accounts for 10% to 15% of new aircraft sales,** plus a large replacement and foreign market. One stimulus to higher sales, Stimpson says, occurred when the House Appropriations Committee postponed for a year the FAA's imposition on plane owners of $50 million in user charges.

NSF program seeks to involve firms in local government

The National Science Foundation soon will be asking electronics and other companies to sign up in **an experimental program aimed at increasing non-Federal research and development in local government.** Besides the public service aspect, the four-year $4.1 million program also should help participating companies get a better feel for the municipal marketplace. Called the urban technology system, the technology transfer program will use companies, universities, think tanks, and Federal laboratories as technical support to the 27 local governments to be named by the end of the year.

Addenda

The Navy expects to be able to **salvage at least half of the 52% slashed from the $1.7 billion Trident ballistic missile submarine program** by the Senate armed services R&D subcommittee. The fiscal 1974 request—nearly $1.2 billion for the first boat and $500 million for the missile—still requires action by other committees in both houses before a vote. . . . The FBI is again marked by industry as "a growth market" now that its leader is former Kansas City police chief Clarence Kelley, **a leading advocate of electronics in law enforcement** [*Electronics,* Dec. 6, 1971, p. 39]. . . . Reorganization of the U.S. Customs Bureau should produce a series of piecemeal buys for its **$60 million national net of 1,800 computer terminals in the Automated Merchandise Processing System,** originally planned for procurement under a centralized five-year plan beginning in 1974 [*Electronics*, March 13, 1972, p. 42].

Making design-to-cost work

At a seminar of the Electronic Industries Association, Harry M. Taylor, president of the Logistics Management Institute, recently examined the Defense Department's new design-to-cost policy for military procurement. Excerpts from his presentation follow. —*Ray Connolly.*

The fundamental problems suffered by the DOD today seem to me to fall into two categories. The first is cause; the second, effect. In the first category, I have included five problems which . . . are very basic to weapons system acquisition. . . . They are: (1) lack of integrity in the acquisition system, (2) excessive size of the defense industry, (3) excessive speed by DOD to field new systems, (4) inadequate use of effective competition, (5) too many twists and turns in acquisition policy compounded by poor communication and worse training.

. . . Lack of integrity can be stated this way. No one believes anyone will behave the way the formal system anticipates. No one believes the system works by the written rule. Everyone believes the written rules are a mere formality and that the unwritten, informal rules (which everyone thinks he understands) are the ones that really count.

I once heard a DOD official ask another official, "When is a fixed price fixed?" The somewhat cynical response was, "Rarely—if ever." What was meant was that in a crunch—when a weapon system to which DOD is committed is threatened with failure because of cost growth—the distinction between fixed-price and cost-reimbursement contracts tends to vanish.

. . . There is an overwhelming consensus in industry and Government that there are simply too many companies depending in whole or in substantial part on defense business for their welfare. . . . Overcapacity results in greater cost to the taxpayer and that's why DOD—if for no other reason—should be concerned.

Impatience

It seems to me that in the past there has been great pressure within DOD to make decisions and commitments to hardware before anyone is smart enough to make such decisions. The process will not tolerate shortcuts or premature commitments without exacting severe penalties in the form of performance and cost degradation. . . .

There seems to be no clearcut commitment to competition at either DOD policy or operating levels. . . . What I think is needed is a clear and obvious commitment on the part of the DOD to design/price competition between or among alternative systems, with a heavy burden imposed on those who would avoid competition, to justify their judgment. . . .

Regarding my fifth conclusion—that there are too many twists and turns in acquisition policy—it seems to this observer that at least since 1960, major policy changes have been coming so fast that it has been exceedingly difficult—if not impossible—to make a judgment about a policy before it is changed. . . . Those charged with responsibility for executing the numerous policies issuing from above would undoubtedly benefit if a moratorium on major changes were declared for several years, during which those responsible for communicating and interpreting policies and training lower echelons can do so with some confidence that what they teach will be relevant for somewhat more than a fortnight.

Credibility gap

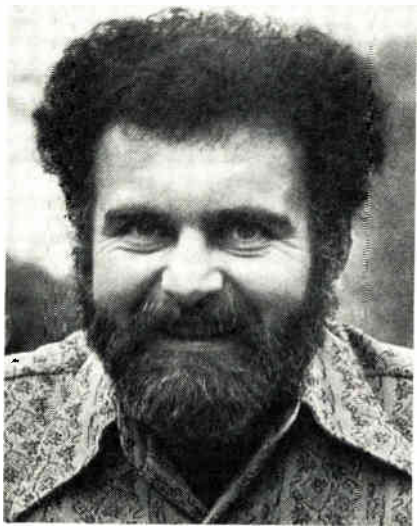
I stated earlier that my five conclusions fall into a category I called "cause." The other category—namely, "effect," according to my scenario—contains only one fundamental conclusion. It seems to me that the significant effect of the problems . . . is the evolution of a serious credibility gap, not only with respect to estimating future costs but also with respect to controlling actual costs of weapons systems . . . a serious problem which not only imperils public support of the DOD but more importantly imperils the defense posture of the nation.

. . . With the parallel effect of limited budgets and increasing costs . . ., the DOD must find ways to achieve a better balance between quantity and performance on the one hand and costs on the other. Design-to-a-cost is another in the never ending struggle to reach that objective. . . .

If the ceiling is supposed to represent the maximum unit production price with no consideration of ownership or life cycle costs, I fear contractors will succumb to an irresistible temptation to game the DOD right out of its shoes, be they black or brown. I defy anyone now or in the future to fix the unit production price before a system is designed and, at the same time, make valid tradeoffs between price, performance and life-cycle cost. I don't believe it can be done. The only hope lies in the inclusion of life-cycle costs in the ceiling, not outside it. The concept of floating performance and fixed ceilings, in my judgment, is no solution at all. It is only the obverse of the old problem.

Godzilla Meets The Linear Monster

Godzilla, alias Bob Widlar, is the well known king of the linear IC underworld. Teledyne, on the other hand, is known as the semiconductor and IC producer of monstrous proportions. We compete in just about all areas of IC's. When we started out to do battle in the linear market, we came up against Godzilla's forces; the 101, 101A, 105, 107, 108, 108A, etc. Now that's a formidable line. You see, Teledyne, though big, is friendly. To oppose such a line would be contrary to our normal cordial, compatible, helpful



nature. So the only thing to do is join Godzilla's forces. After all, Teledyne can do it in a very big way.

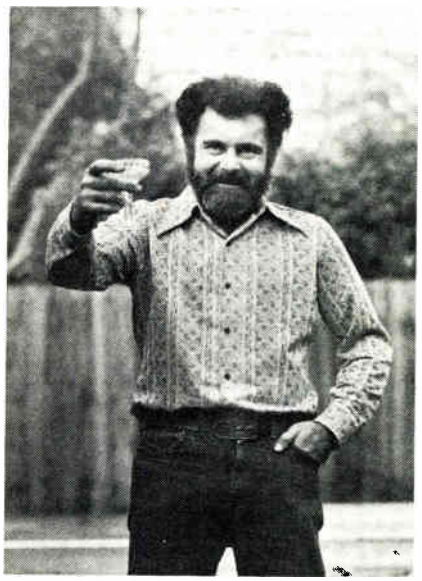
Now, here's the line-up and we're ready to take on all comers:

101 Operational Amplifier
101A Operational Amplifier
105 Positive Voltage Regulator
107 Operational Amplifier
108 Operational Amplifier
108A Operational Amplifier

Just to prove how friendly we really are, we'll give you ***absolutely free*** one of the above (1 only) IC's . . . plus a signed picture post card of Godzilla . . . if you send us a note on your company letterhead and tell us why you want one free.

Note: Bob Widlar; inventor of the 709, 101, 105, and 108; does not work for Teledyne Semiconductor. Bob Widlar does not work.

I'll drink to that!



the challenger

TELEDYNE SEMICONDUCTOR

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Optical waveguide shares chip with active elements

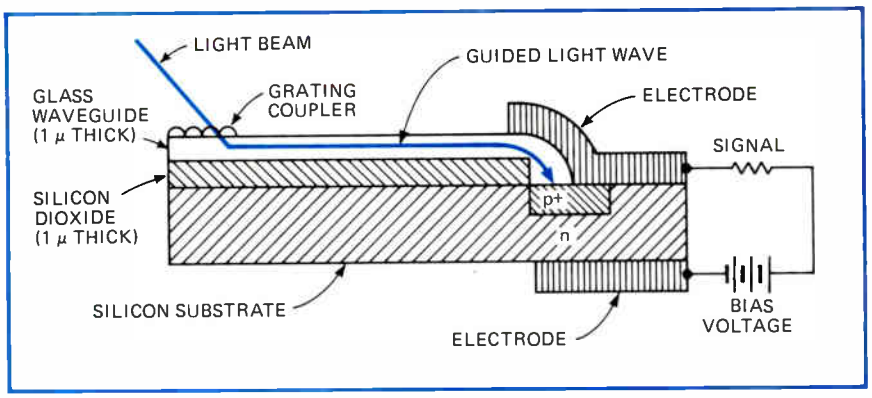
No one who has really thought about it doubts that telecommunications networks around the world one day will have billions of dollars in their budgets earmarked for optical communications hardware. It is hazardous to predict, though, whether the day will come in the very late 1970s, the early 1980s, or even the mid-1980s. But it is safe to say that it is high time for hardware companies that want a piece of the market to start piling up optoelectronics know-how.

R&D. The pile is building up fast at Thomson-CSF, France's largest professional electronics producer. Something like 10% of the 500 researchers at the company's Corbeville basic research facility on the outskirts of Paris are involved—not always full time—in work related to optoelectronics. Thomson-CSF has opted for a systems-oriented approach and already has pushed some hardware into development at producing divisions.

This first hardware stacks up as relatively simple: an incoherent light-emitting-diode source, directly modulated, linked to a detector through a glass-fiber cable. But this equipment, built around discrete components, is just a beginning. Corbeville already has to its credit some experimental optical integrated circuits, fabricated by a group headed by Dan Ostrowsky.

Ostrowsky, an expatriate American, emphasizes that "there's a tremendous distance to go" before integrated optical communications becomes a mature technology. "We are learning to do with light what people can now do with microwaves," he points out. The group has already learned to combine optical waveguides and electronic elements on the same silicon substrate. It has also worked out the basic technology for duplicating optical ICs. "We can make them," Ostrowsky says, "but we really don't know how to look at them yet." In his view, there's much work to be done in instrumentation before optical ICs can be readied for systems markets. Coupling light in and out of optical ICs also rates as a major problem and there's a crying need for practical optical connectors.

Nonetheless, progress so far at Corbeville with optical ICs has been impressive. Ostrowsky's group has, with its integrated optical photodetector, scored a first in optoelectronics. It combines a grating coupler, a glass waveguide, and a single photodiode on the same substrate. More important, it points the way to complex circuits mating passive optical waveguide elements, such as beam dividers and filters, with active electronic elements, like detectors.



Down the pipe. In Thomson-CSF's integrated photodetector, a sputtered-glass optical guide channels light hitting surface to the diode.

For the photodetector, the Corbeville group started with an n-type silicon substrate having a resisitivity of 5 ohms/centimeter. Then came a silicon dioxide layer 1 micrometer thick. This layer serves mainly as isolation between the glass guide structure and the silicon substrate. But it was also used as the mask for diffusing in boron to get a p+ region 1 micrometer deep for the photodiode. Once the diode was in, a glass waveguide 1 micrometer thick was sputtered on, using a mask to form a coupling taper that beams light onto the diode. To couple the incident beam into the waveguide, a holographic grating coupler goes atop the guide.

Size. Losses run about 0.8 decibel per centimeter, which the Corbeville group thinks is acceptable. The photodetector, though, would be too slow for a full-fledged IC. That is because the surface of the diode junction is relatively large—1 millimeter in radius—and that boosts the capacitance. As a result, the rise time works out to 15 nanoseconds when there's a 50-ohm resistance across the diode and the reverse bias is 10 volts. In an actual IC, the diode radius could be about 10 micrometers, slashing rise time to about 15 picoseconds.

For the Corbeville optoelectronics team, waveguides 10 micrometers wide are no challenge. They can lay down guide structures 5 micrometers wide and 1 centimeter long with spacings of 0.5 micrometer. Especially important for light guides, the edge roughness is less than 400 angstroms.

The aspect ratio for waveguides that fine runs as high as 20,000:1. Crucial to getting this precision is an

electron-beam mask-cutting machine developed at Corbeville mainly by Jacques Trotel. The masker works under computer control in a positioning system that has a laser interferometer to determine the position of the carrier table within 400 angstroms [*Electronics*, Feb. 15, 1971, p. 154]. Any differences between the actual position and the correct position are covered by deflecting the electron beam. All told, the accuracy is 1,000 angstroms between any two points over a 5-by-5-cm surface.

And Ostrowsky's group has come up with materials that make the most of the masking machine. They spin-coat polyphenyl siloxane dissolved in benzine onto a silicon substrate that has been thermally oxidized to obtain a silicon-dioxide layer slightly more than 1 micrometer thick. The PPS forms a negative-resist film about 5,000 angstroms thick after it has dried. The waveguide patterns are then written into the PPS by the electron-beam machine, and they remain when the PPS film is developed in benzine. A typical light loss for a PPS waveguide is 1 dB/cm.

Turning out precision waveguide structures one at a time in an electron-beam masker—it can take up to three hours to expose a substrate—will obviously be out of the question when optical ICs actually go onto the market. So Corbeville has begun working on ways to duplicate them.

Masking. One approach that looks promising is a master mask with palladium atop a titanium dioxide pattern on a glass substrate. Illuminated from the underside by ultraviolet rays, the mask emits electrons wherever there's no titanium dioxide underlying the palladium. These electrons can be accelerated and focused to expose a waveguide pattern in a PPS or other film. It only takes about five minutes to duplicate waveguides this way. The precision, of course, doesn't match that of the computer-controlled masker. But it's adequate: Some 2,000 angstroms between any two points over a 5-by-5-cm surface. □

Around the world

Japan speeds computer, IC decontrol

The Japanese government's decision to liberalize—that is, decontrol—computer imports "at an appropriate time" during 1975 brings the day of real competition much earlier than Japanese computer manufacturers had expected [*Electronics*, March 15, p. 55]. And the government's move to do the same for integrated circuit imports during 1974 doesn't leave much time either. Since foreign capital investment in these products will also be liberalized during the same years, American and other foreign companies will have relatively free access to the Japanese electronics market.

Computer capital investment will be liberalized in two steps. First comes a liberalization of up to 50% by August 1974. The second step will be liberalization of up to 100% of investment in December 1975. Capital investment in ICs is now on a case-by-case basis and will remain that way until a one-step liberalization of up to 100% in December 1974.

Finger replaces CRT's light pen

A finger moving across a CRT display surface has the same effect as a light pen in a graphics display developed by two engineers at Essex University. They believe the convenience of not having to hold a pen gives their system some commercial appeal. Last month, Automatic Radio Inc. of Melrose, Mass., which financed the work, took delivery of a demonstration display and is trying to interest computer-equipment makers in it.

The system works by using the operator's body and the display surface as current paths, and the circuit is joined when the finger touches the screen. The point of contact is measured in terms of the split in current flow between edges, giving X and Y coordinates, and this information is used to control the tube deflection systems. John Turner and Gordon Ritchie, the two engineers, have built two displays with usable screen areas of about 8.5 by 6.5 inches.

GaAs diodes climb in power, frequency

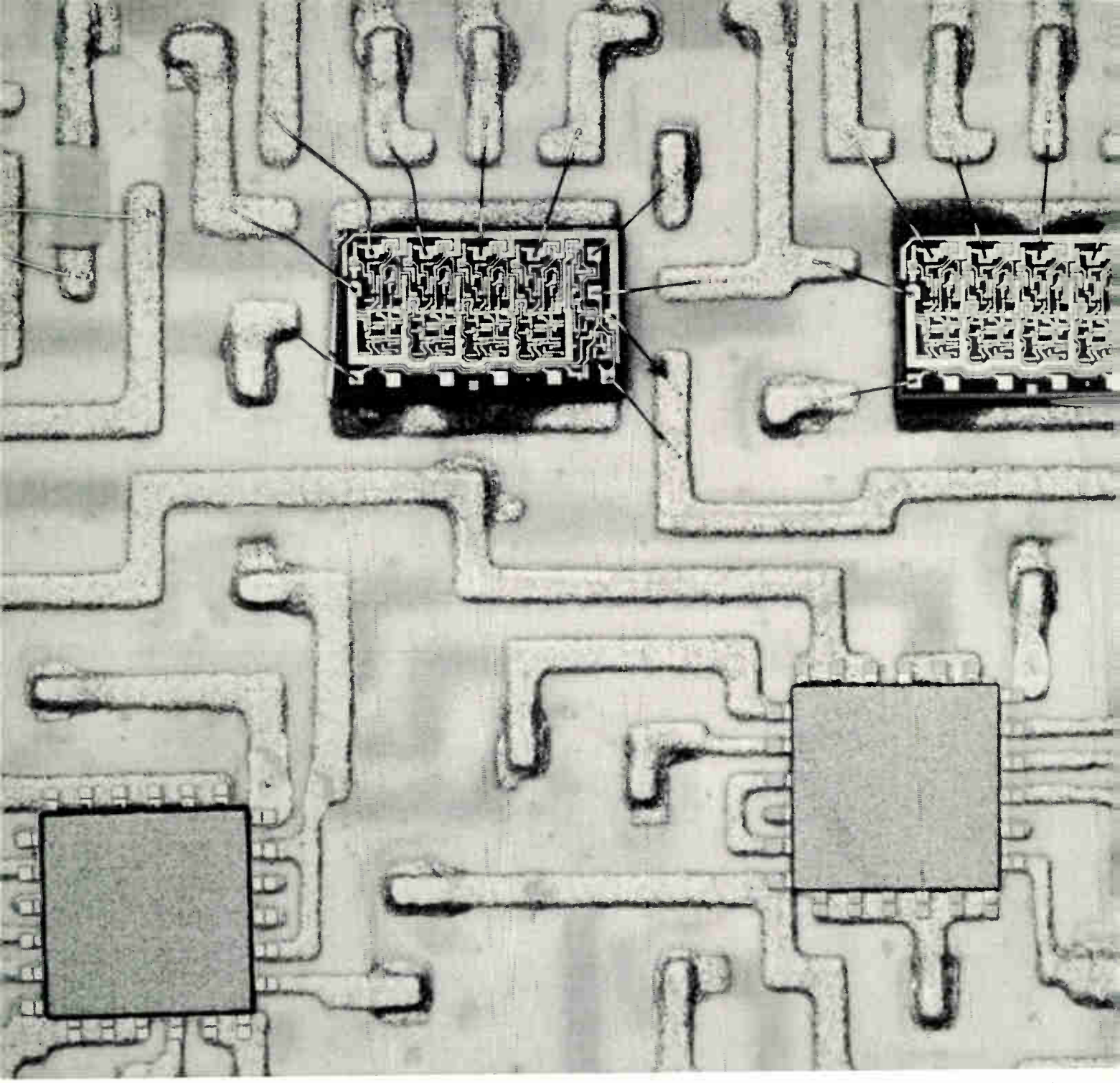
A research team headed by Andrei Mircea at Laboratoires d'Electronique et de Physique Appliquée has pushed past the 20% mark in efficiency with gallium arsenide avalanche transit-time diodes operating in the X and C bands. Some researchers in the U.S. have gone a few percentage points higher, but LEP has advanced to the point where another unit in the Philips group, RTC-La Radiotechnique Compelec, plans to put the ATT diodes into production. The first product in the range should be ready toward the end of the year. It most likely will be rated for 500 milliwatts or more output at a center frequency of 12 gigahertz, with efficiency higher than 12%.

LEP has done much better than that with laboratory versions. In efficiency, it was gone up as high as 22% at 7.5 GHz with 600-mW output. At 12 GHz and 500 mW, the figure reaches 18.5%. As for power, single diodes have made it up to 1.5 watts at 8 GHz. And the lab has put ten of the 600-mW diodes together in a single cavity to get a microwave source that develops a 5-W output at 12 GHz with an overall efficiency of 8%.

Solid-state converter for TV movies

Looking to the day when electronic image-sensing systems—TV cameras for example—will be entirely solid state, engineers at the British Broadcasting Corp. have built a film-to-TV conversion system using a linear silicon photodiode array to scan the film instead of the usual flying-spot scanning system. It's a study project, to see what sort of picture the diode array will give, and while not for operational use the system gives a monochrome picture of fair quality.

The array, from Reticon Corp. of Mountain View, Calif., is a standard 512-diode device—the longest so far available—integrated on a single chip with MOS scanning circuitry. The diode pitch of 1 mil eases matching the film width to the array length. A total of 512 sensor elements is just about enough to give adequate resolution. And the Reticon device will clock along the array at 10 megahertz, so that one horizontal scan takes 51.2 microseconds, which is almost the same time as the standard 52-microsecond active line time of the European TV format. The small amount of black at the edges is not perceptible.



Are beam-lead or chip-and-wire hybrids best for your circuits?

Ask Raytheon.

Beam-lead hybrids for your circuits? Or chip-and-wire? If you're not sure which is the most *cost effective* for you, ask Raytheon. We've got extensive experience in both areas. In fact, no one can match our experience in packaging hybrids with beam-lead devices.

We can tell you when rugged, reliable beam-lead technology will beat chip-and-wire hands down in overall circuit cost-effectiveness. Or we can tell you just as quickly when the lower unit cost of chip-and-wire is the best choice for greater short *and* long term savings.

Either way, Raytheon custom hybrids are the first choice for quality and reliability – in ECM, telemetry, radar, and medical electronics circuit applications. Either way, we can show you which is best in *your* circuits. And we have the applications, design, volume production, and quality assurance experience to back up the recommendation. Contact Raytheon Company, Industrial Components Division, 465 Centre Street, Quincy, Mass. 02169.

RAYTHEON

Circle 58 on reader service card

International newsletter

Philips, Siemens, and CII finally found Unidata

Philips, Siemens, and Compagnie Internationale pour l'Informatique have signed their long-awaited agreement setting up a joint computer company, Unidata. For the next year or so, Unidata will sell the current product range of its parent companies. **A new model range, from desk-top to very large machines, has been under development for some time and will be launched progressively from about 1975 onwards.** All models will be compatible with IBM systems.

Product development stays in the hands of the parent companies, but sales, technical service, and finance will be handled by Unidata companies. For legal reasons, Unidata has set up three headquarters companies—in Munich, Paris, and Apeldoorn, Holland—but will have a single management team headed by the two computer division chiefs at Philips and Siemens and by CII's director general. These three companies, to be known as Unidata Management, will in turn control three relatively independent sales companies with a common holding company in Amsterdam.

Unidata hopes to add other European computer groups to its stable sometime, but points out that Britain's ICL is still designing new models that are not compatible with IBM systems and shows little sign of wanting to join in. Meantime, Honeywell-Bull is talked of as a possible partner, although Unidata is playing cool for the moment.

Britain aids ICL and domestic IC makers

The British government is showing increasing willingness to pump public money into British electronics companies where it judges it's in the national interest. First, it has announced that **International Computers Ltd. will get $65 million over the three years starting in September 1973 to make sure ICL's new range of computers, due later this year, is properly launched and established.** ICL is already receiving $35 million over the two years prior to that as direct R&D support for the new range. ICL estimates that this $100 million is about one-quarter the total cost of developing and introducing the range.

Second, the Ministry of Defence will progressively increase financial support for development in Britain of custom integrated circuits with expected military applications. Companies that will benefit are the British-owned IC makers, Ferranti Ltd., Plessey Co., and GEC Semiconductors Ltd., and the Philips subsidiary, Mullard Ltd. **The aim is to reverse the present trend in which the number of contracts for British custom ICs for domestic military equipment is actually falling** because the IC makers cannot meet the equipment makers' time scale. Now equipment makers will be asked to write outline IC specifications much earlier so that MOD can start more projects and start them earlier.

Nippon Electric goes after European market

Nippon Electric is putting increased emphasis on exports, especially to Europe. Until recently, Nippon Electric had liaison offices in Dusseldorf and Vienna. **In May, it advanced the Dusseldorf office to a subsidiary, NEC Electronics Europa,** with responsibility for selling components and consumer electronics. **Last month, it established a liaison office in Warsaw and an English subsidiary, NEC Telecommunications Europa.** The English subsidiary also provides backup for the liaison office established in Nairobi, Kenya, last year; much of the business for Africa flows through London.

International newsletter

Video cassettes for consumers launched in Sweden

The first effort in Europe to market video cassette systems for private consumers will be launched this fall in Sweden, Finland, and Norway. **Although video cassettes have been marketed for special groups—such as schools or training programs—this will be the first effort to crack the big consumer market.** Behind the project is European Television International Svenska AB. Known as ETI, it is a subsidiary of a Swiss financial group, European Programming Consolidated Foundation.

ETI will market its programs and recorder/players through a club system. In Sweden, individuals will pay a $37 entrance fee, plus $30 monthly over a five-year contract period. This will give the member his choice of two cassette programs a month, selected from a 5,000-title catalog and a service warrantee on the recorder/player, which he will own at the end of the contract. The member will plug the player into his own black-and-white or color receiver. ETI is also offering its players and programs on a hire-purchase plan to bars and pubs, which will get sports and entertainment programs mixed with commercials.

Plessey expands industrial IC line

Plessey Co.'s integrated-circuit division, which so far has concentrated on military, consumer and custom IC markets, **plans to shift the emphasis towards industrial markets for off-the-shelf special-purpose ICs.** First products to be pushed will be based on custom designs no longer exclusive to the original customer. Included will be a range of MOS analog switches useful mainly for building multiplexers; an MOS 10-channel current amplifier that will give 250 milliamperes into 24 volts from each channel; a bipolar op amp with a slew rate of 175 V per microsecond, allowing the output to settle to 1% of final value within 50 nanoseconds; and a bipolar phase-locked-loop modulator/demodulator. This unit will lock on to any input frequency up to 2 megahertz, so can be used to extract a signal from noise.

Siemens lands more East Bloc computer orders

Siemens AG has boosted its East European order backlog by several million dollars through deals with Czechoslovakia and Hungary. One contract covers the delivery of **$3 million worth of EDP equipment for a computer center in Bratislava.** From there, two Siemens machines, a 4004/45 commercial system and a 404/6 process computer, will be used for controlling rail traffic, tracing freight cars on international routes, and handling various other administrative tasks. The contract from Hungary is for four models of the 4004 series, which will be used by banking institutions and government agencies. This order will **bring to 10 the number of Siemens 4004 systems in Hungary.**

German typesetter speeds composition of Japanese symbols

Germany's Rudolf Hell GmbH, a big equipment supplier to the printing industry, has come out with a high-performance digital electronic phototypesetting machine for Japanese characters. **Successful trials with the first system at the Japanese daily Mainichi** have led to an order for a second one by that organization. The system, Hell says, reaches a typesetting speed of over 100 characters per second, a speed which was previously impossible to achieve when typesetting very fine Japanese characters. The system works on-line with the Digital Equipment Corp.'s PDP-11 computer, which is equipped with two disk stores **with a capacity of over 40,000 Japanese characters.**

Buying a function generator isn't a big deal.

Using one every day is!

Because there's not much difference in function generator prices, there is often a tendency to specify the "name" brand. But **handle-ability** can be an essential factor. When a basic signal-source goes into your lab, consider first the **day-to-day efficiency** of the instrument and **its effect on the real cost of ownership.**

For example, with sweep width a critical factor in testing network frequency response or developing a response plot, INTERSTATE's F34 allows you to precisely dial the controlled starting and end points. This, coupled with a Sweep Limit Indicator that won't let you dial an invalid output, puts it miles ahead of Wavetek's 134 for accuracy and ease-of-use.

This, and many other human engineering and price/performance differences that exist between the two function generators reflect INTERSTATE's continuing concern for the user and are factually catalogued in our FREE specifier guide. Check the number below to receive it, or for more direct information, call John Norburg, (714) 772-2811.

"THE $495 COMPARISON:
INTERSTATE F34, WAVETEK 134 FUNCTION GENERATORS."

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Circle 61 on reader service card

AVX takes the bull by the horns AGAIN

AVX makes another bold move. First, in ceramic capacitors.

Now in ceramic filters.

AVX recently acquired the Potter Company California Operations. This merging of capabilities results in the industry's most comprehensive line of EMI filters.

The present filter facility in San Diego will be expanded. Production will include miniature and micro-miniature low pass EMI filters. C, L, 2L, Pi and T networks. Buttons, bolts, eyelets and hexes. Anything and everything in a wide range of ratings. Plus — AVX quality at the right price.

Order any AVX or Potter filter from our West Coast facility. Request the new AVX Filter Catalog. Write, AVX Ceramics , 10441 Roselle Street, San Diego, California 92121. Telephone: (714) 453-6610.

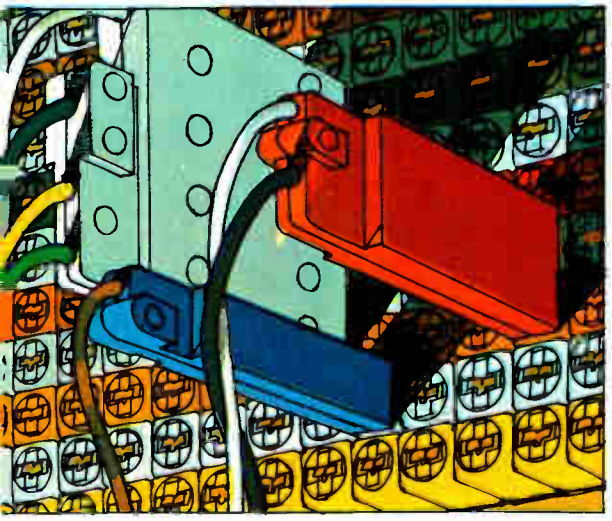
AVX

THE CERAMIC FILTER MANUFACTURER

AVX CERAMICS CORPORATION

Growing with the

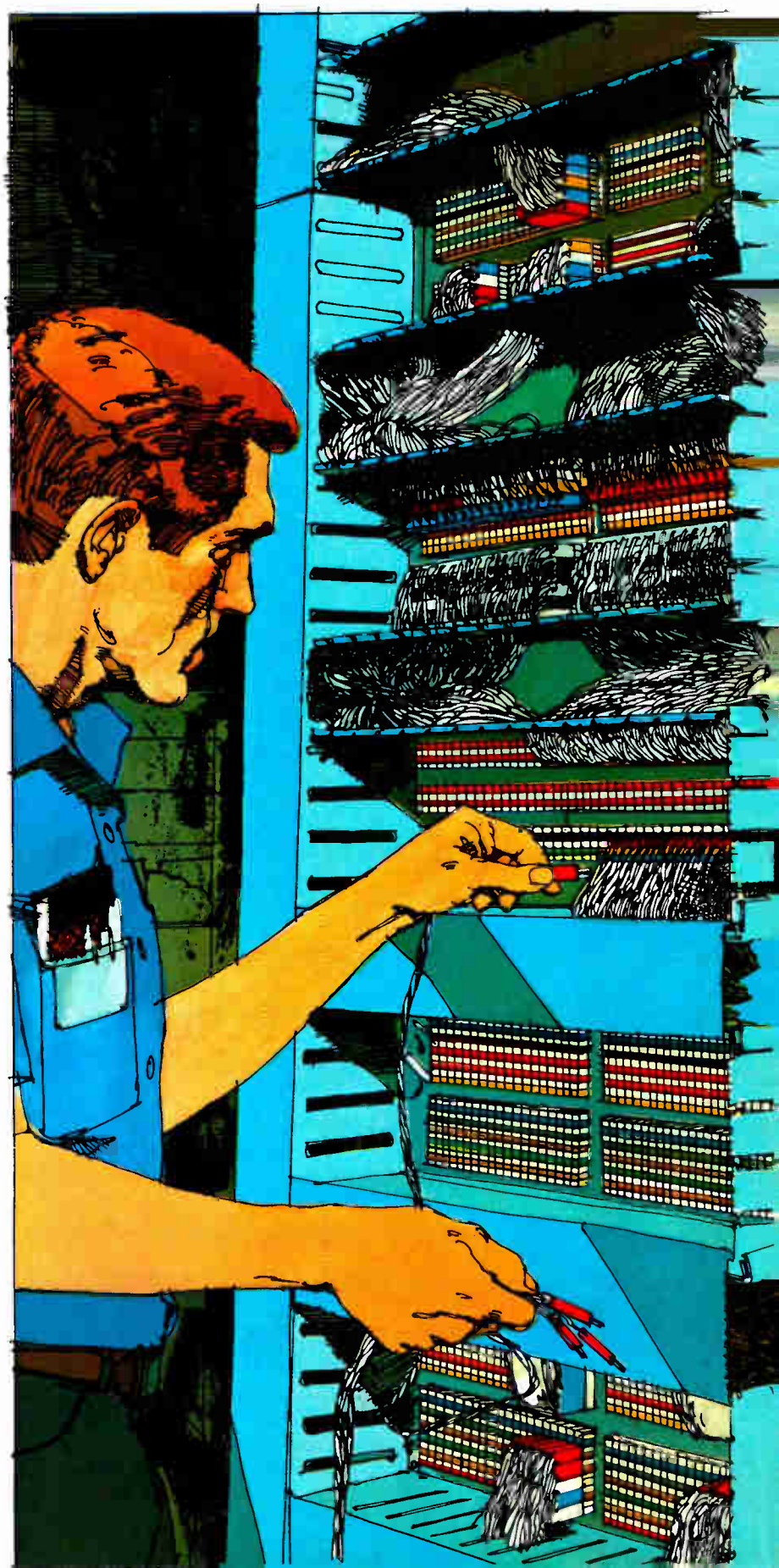
Amphenol's new telephone connector system saves space, saves time, saves material.



It's called Circuit Concentration Bay (CCB) and was first used to alleviate the problem of overcrowded distributing frames in a major Colorado telephone company central office. More than five miles of cable were actually eliminated in this installation. Floor space requirements were reduced by 80 per cent.

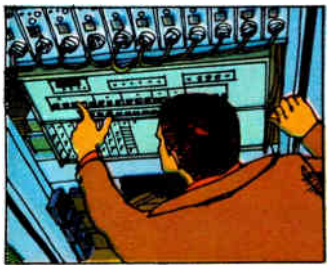
As more and more phone companies gain experience with CCB, it is also becoming clear that the savings in labor are at least as great as the space savings. Instead of the tedious, time-consuming job of hand soldering each connection, the craftsman uses color-coded miniature patchcords to complete circuits in about one-twentieth the time. And circuit interruptions found in normal distributing frames are virtually eliminated.

The savings in space, materials and labor due to Amphenol's CCB system are adding up to tremendous cost reductions and improved service for phone companies across the country.



new electronics

Amphenol connectors help a mini-computer control a 70,000 vehicle intersection.



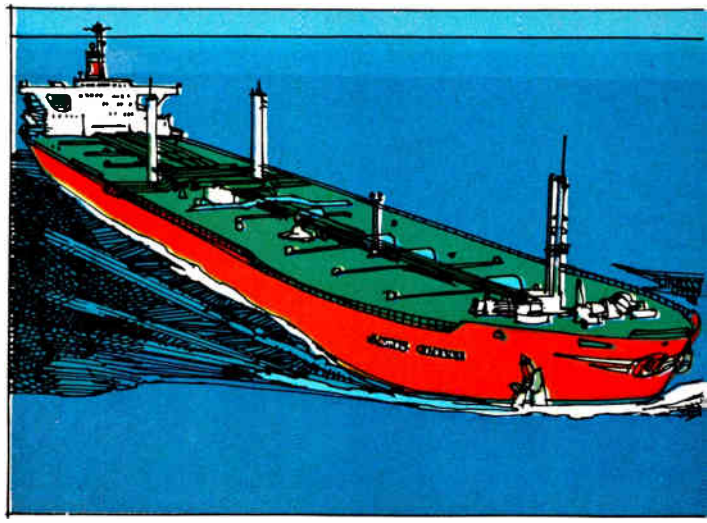
A sophisticated traffic control computer was installed last year to tame an unusually busy intersection in Campbell, California.

Environmental problems are tough because the controller is located right at the intersection. It must remain unaffected by temperature variations between 0 and 120°F. and by voltage variations of plus or minus 10 per cent. It must perform faithfully for years to come.

That's why Amphenol's 5015 series connectors were selected. Our "Old Vet" has a service record in tough environmental conditions that no one can match. Some "Old Vets" are in service after over 30 years on the job.

That's important to Campbell, California because their traffic controller has a lot of work ahead of it.

Amphenol digital turns-counting dials help load a ship by computer.



Unless a ship's cargo is distributed just right, stresses can cause extensive hull damage. So proper load distribution is critical. That's why one of the world's largest shipbuilders has developed an electronic cargo distribution computer. It presents cargo placement and hull stress information continuously.

The Swedish manufacturer selected Amphenol dials for this computer because they're so easy to read. A magnifying window significantly enlarges the numerals and vernier scale, and digital readout is angled to the perpendicular for easy viewing from all positions.

Easy readability of the computer input devices is essential because a misread digit, when fed into the computer, could cause a disastrous error in loading.

BUNKER RAMO **AMPHENOL**

For more information, contact these manufacturing/sales facilities. United States: Amphenol Sales Division, 2875 S. 25th Av., Broadview, Il. 60153 **Canada:** Amphenol Canada Ltd., 44 Metropolitan Rd., Scarborough, Ont. **Great Britain:** Amphenol Ltd., Thanet Way, Tankerton, Whitsable, Kent, England **West Germany:** Amphenol-Tuchel Electronics Gmbh, 8024 Deisenhofen bei Munchen, West Germany **France:** Usine Metallurgique Doloise, 92a98 Avenue de Gray, 39100—Dole, France **Australia:** Amphenol Tyree Pty. Ltd., 10-16 Charles St., Redfern, N.S.W. 2016, Australia **India:** Amphetronix Ltd., 105 Bhosari Industrial Area, Box 1, Poona 26, India **Japan:** Daiichi Denshi Kogyo K.K., 20, 3-Chome, Yoyogi, Shibuya-ku, Tokyo, Japan 151

Circle 65 on reader service card

"When we evaluated Augat's interconnection system we hardly believed we could get both superior design flexibility and lower cost.

"Now we believe it."

Ed Herr
Manager of Materials/Storage Systems Dept.
Clark Equipment Company

"Clark automated storage systems utilize a computer-directed stacker crane and transfer cars. The heart of the system is a Clark-designed electronic logic package, with Augat plug-in control circuit boards.

"About half of each logic/system we deliver is custom-designed to meet specific requirements. Use of Augat panels means faster development time. We stay competitive because we can design and deliver a complex system faster, with a lower overall cost.

Ed Herr

"We also save a lot of time, and thereby money, with Augat's easy field maintenance. Trouble-shooting in the field is simple, chip replacement or rewiring can be done on site. By replacing individual components instead of complete board assemblies field maintenance is faster and customer downtime is kept to a minimum.

"Augat panels also allow us to remain responsive to customer-requested changes and additions to the system we deliver. This is a direct result of the flexibility inherent in wire-wrapped socket panels.

Automated Transfer Car

"Stacker cranes often work 24 hours a day in a rough, punishing environment. We wondered if a socket approach could withstand the constant shock and vibration. So far, we haven't experienced a single malfunction.

"Using the Augat approach makes life easier."

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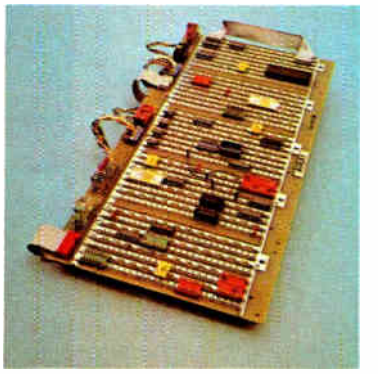

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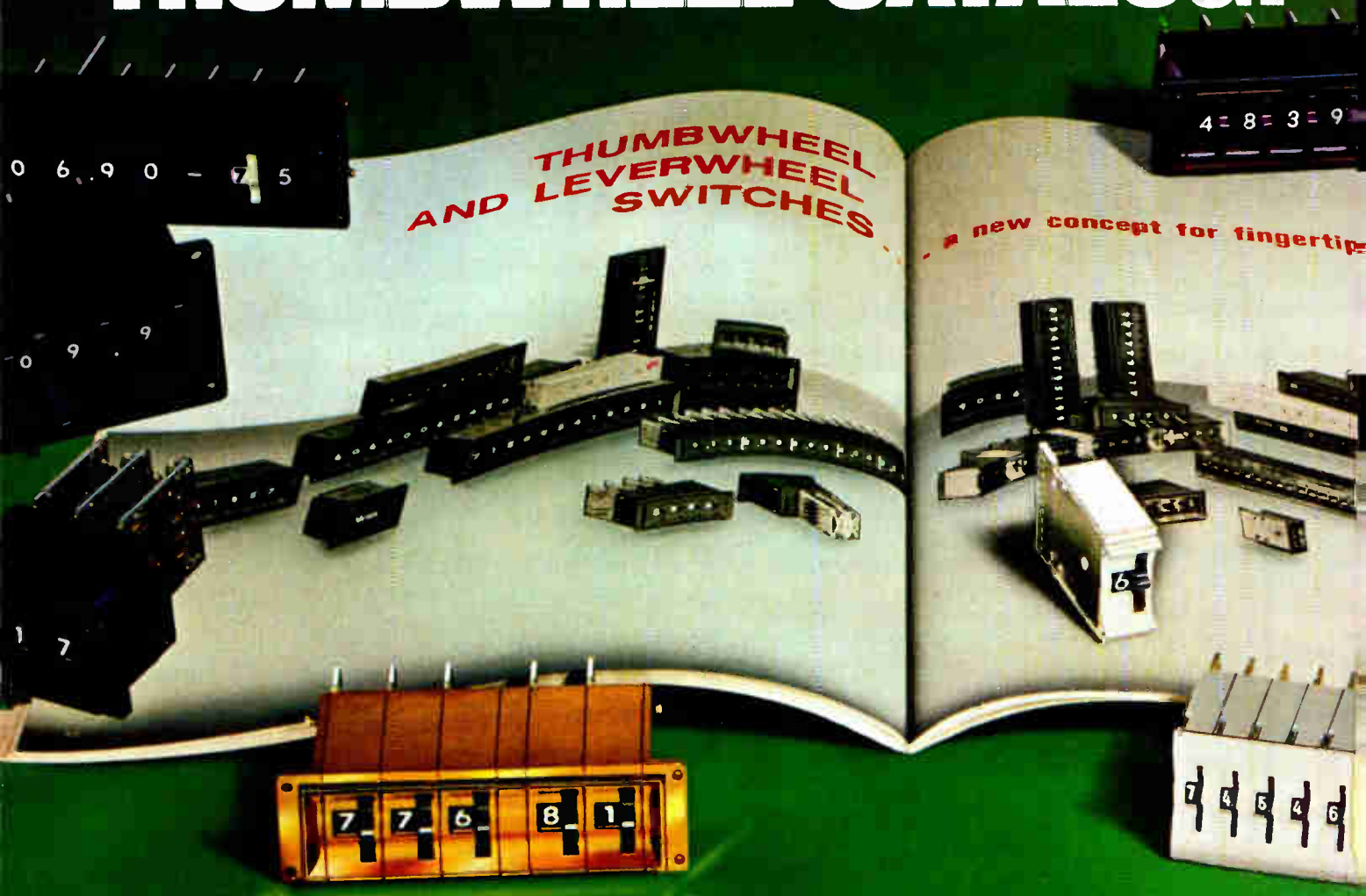

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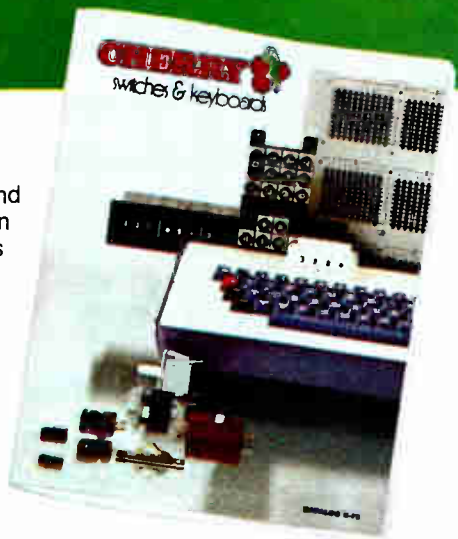

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Circle 68 on reader service card

Sales of earth terminals set to soar

Birth of national and regional satellite systems spurs demand for smaller solid-state stations costing less than $1 million

by William F. Arnold, Aerospace Editor

Up to now a typical earth terminal has had a huge dish antenna, fancy hardware, and an equally fancy price tag of $3 million to $5 million. However, the emergence of national and regional satellite systems to supplement the global trunk network—coupled with advances in solid state—is opening a new market where sales will go up while the size and cost of terminals go down. Trends affecting the market and technology include:

- A growing demand for medium-sized and small terminals, with special emphasis on remote, rooftop, and unattended stations, many of them receive-only units for TV.
- Smaller trunk stations for telephony and television transmission, their 30-foot antennas mandated by economics and made possible in part by increasing circuit miniaturization.
- More digital communications, mostly built around time-division multiple-access (TDMA) approaches for heavy-traffic terminals, the demand-assigned Spade system [*Electronics,* Feb. 28, 1972, p. 102] for medium-traffic terminals, and single-channel-per-carrier techniques for light-traffic terminals (much of the traffic will be computer-directed at higher transmission rates).
- More solid state, including the wider use of large-scale integration (LSI), which will spur development of cheaper non-cooled parametric amplifiers and other subsystems.
- Falling prices across the board with maximum costs, for example, approximating $1 million for a medium-sized trunk terminal, $400,000 for a Spade terminal, and less than $100,000 for a single-voice-channel unit with TV-reception optional.

The result is potentially a global market where, despite fierce economic and technological competition, new companies will join the scramble for sales with their more established competitors. Not surprisingly, American and European companies, while concentrating on their respective domestic systems, find tough competition from Japanese companies in Intelsat and so-called third world markets in Africa, Asia, and Latin America.

Japan is the big competitive threat, asserts Robert Chasen, group general manager of ITT's Government and Commercial Services division, Nutley, N.J., who calls Nippon Electric Co. and Mitsubishi Electric Corp. "formidable competitors." He and other executives say the Japanese are off to a good start in digital work through intensive research and development, for example.

Big four. Worldwide, the big four companies appear to be ITT, General Telephone and Electronics, NEC, and the Italian syndicate STS, in which GTE's Italian subsidiary has a minority holding. STS, for example, beat out ITT and NEC and other major leaguers for work in Sweden and Argentina. While ITT is three or four times larger than any other supplier of earth stations, NEC has a good share, too. It sold Spade

Cool calls. Thin-route earth station in the far north uses single-channel-per-carrier voice circuits for Bell of Canada telephone service.

equipment to eight European countries, as well as in Asia and Africa, and claims to have sold equipment for nearly half of the world's 70-odd commercial earth stations.

But right now, supplying the world market is not profitable, say ITT's Chasen and Richard W. Couch, president of GTE's International Systems Corp., Waltham, Mass. The big future market lies in domestic satellite communications systems, Couch says. However, he believes that overseas both the international and domestic systems will be locked up by national companies, particularly Marconi Communications Systems Ltd. in Britain, Mitsubishi and NEC in Japan, Thomson-CSF in France, Siemens in West Germany, and STS. Aside from these companies, he says, "Europe is almost closed."

Two coming. Besides Canada's Telesat system, that would leave two big domestic networks coming up. One is the U.S. net now getting under way [*Electronics,* June 21, p. 72], and the other is the 2,500-earth-station Brazilian system that's being planned. To follow those are networks in Australia and India. In the U.S. "do you know how many earth terminals there'll be in private wire service alone?" exclaims Alfred M. Faries, senior engineer in satellite systems development, RCA Global Communications Co. His excitement is shared by many vendors: companies are becoming serious about business in earth terminals because "some realize that there're hundreds of millions of dollars staring them in the face," he says.

U.S. equipment suppliers ITT, GTE, and RCA are joined by Hughes, Philco-Ford, Radiation Inc., Comtech, Scientific Atlanta, and General Electric's space center in Valley Forge, Pa., which has developed an all-purpose communications system costing $150,000 and up. Modularized, GE's satellite terrestrial setup uses demand assignment and has single-channel-per-carrier circuits. Other foreign suppliers include Japan's Fujitsu; France's Telspace, which has sold 13 $3 million Intelsat terminals; and West Germany's Resatellite Communications Systems, a consortium of electronics companies developing an Intelsat-type TDMA system.

ITT's Chasen, GTE's Couch, and Philip Schneider of RCA Globcom, New York, all see ground-station technology centering on developing unmanned capability and Spade-type switching systems that will provide communications without requiring annual leasing of channels.

Schneider, Globcom's executive vice president for lease facilities and engineering, says the future need is for low-cost broadcasting to many stations. "What you'd like to have is an inexpensive disk [antenna] on your roof," he says. "This means more power from the bird and a change to lower frequencies." Applied Technology Satellite F will show the way, he says, because it will operate at about 900 megahertz and its 30-foot umbrella-like antenna will give much more amplification than present Intelsat birds.

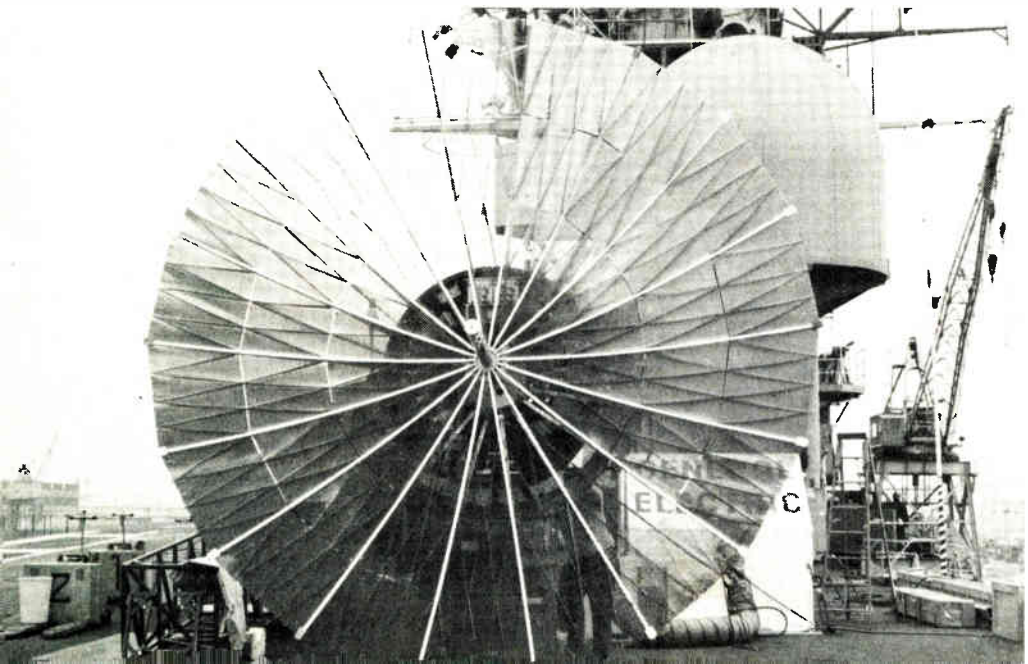
In Japan, NEC says the worldwide demand for new Intelsat-type stations is averaging about 10 to 15 a year, with appropriate sales of medium and small domestic stations. Besides building Spade terminals, development will continue on pulse-coded TDMA techniques for high-capacity applications and the single-channel-per-carrier approach for low-capacity applications. The company expects to complete development of an uncooled parametric amplifier this year—a big step toward lower costs—and would like to work on direct broadcast receivers. Antenna specialist Mitsubishi thinks it's possible to build an antenna-receiver combination for less than $500. It has developed a remote-controlled earth station and is working on a fully automated one.

Price can drop. In France, Jean-Pierre Houssin, chief engineer for space telecommunications at the communications ministry's research facility near Paris, says that prototype stations would sell for much less than $3 million if mass-produced. Light-traffic stations for developing countries could cost as little as $500,000, he adds. However, Houssin cautions that general figures are deceptive because, as antenna-receiver systems shrink, cost of telecommunications equipment for a ground station starts to predominate. And the amount of equipment varies.

Like France, West Germany is developing TDMA systems. Resatellite has developed a 100-megabits-per-second system. Due for Intelsat trials in 1975, the system's Intelsat specs now are a 750-microsecond frame length (instead of 125), 60-megabits-per-second data rate, and the use of a computer.

In England, Marconi is studying a configuration for dishes for data communications which it believes will be 15 feet or less in diameter. The dishes will be needed in quantity, and the company will probably use established technology to keep the price down. □

Carrier carrier. Transportable earth station for TV aboard aircraft carrier used to broadcast all commercial color coverage of Apollo and Skylab recovery operations in the Pacific.



Reporting for this article was by Charles Cohen, John N. Kessler, Arthur Erikson, John Gosch, Michael Payne.

"They're reliability freaks. That's why we bought their laser trimmer."

Mel Nesselroth
Manager, Hybrid Product Engineering
Motorola Communications Division
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"Maybe an hour or so a week, for maintenance of mechanical parts."

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High throughput, total control of trim size, and clear TV monitoring are other features of the W311 that turn Motorola on. But a practical man, Mel Nesselroth keeps coming back to bread-and-butter issues: "I like to think of the savings in support costs we're going to realize because of Teradyne's 10-year warranty. That's a real plus."

Find out more about Teradyne's W311, the workhorse that has proved itself at Motorola and at companies large and small all over the world. Write Teradyne, 183 Essex Street, Boston, Massachusetts 02111. In Europe: Teradyne Europe S.A., 11 bis, rue Roquépine, 75 Paris 8e, France.

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Computers

Sweden enacts privacy law

World's first such measure sets up Data Inspection Board to keep an eye on nation's 4,000 to 5,000 personal data banks

by Robert Skole, McGraw-Hill World News

Sweden is combatting the threat of invasion of privacy by computer data banks. With experts around the world watching, the Swedish Data Inspection Board started operating on July 1 as a watchdog—with teeth—under the world's first national law preventing undue encroachment of citizens' privacy by private data banks. The law regulating establishment and operation of data banks actually goes into effect July 1, 1974—but the inspection board starts operating now to give companies and state agencies a year to comply.

There are 4,000 to 5,000 personal registers in Sweden, among them roughly 500 operated by state or local government agencies. For those 500, the law makes an exception, having the board serve only in a consultant's position. This distinction is perhaps the only point in the law that caused serious debate in its smooth ride through parliament: industry and some political parties wanted the laws to cover all data banks, with no exceptions. But the Social-Democratic government argued that parliament itself provides control of Government systems—and if there are abuses, an individual can appeal to the parliamentary ombudsman.

The government knows all too well about parliamentary control. Last year it sought funds for personnel for a big daddy of all data banks—a central personal register with the information on all Swedes that's now kept by provinces. Data in these banks is public under a 1766 Swedish law, which has been extended to include automatic data processing. But parliament nevertheless objected to the central register and rejected the appropriation, even though the government had to make good on contracts already signed for the computers.

Census sale. The privacy law was triggered in large part by a public outcry several years ago over a special census for data that was going to be sold. At the same time, attention was drawn to the provinces' practice of selling information on individuals when one refused to sell its tapes to an ITT subsidiary. The case went to court, which ruled that the province must treat the tapes as any other public document—and make them available to the public.

Having so much personal data readily available has made Sweden a paradise for direct-mail companies or market researchers. To top it off, all Swedes have personal numbers— given at birth or on immigration— which are valuable for data processing in this nation of millions of Andersons, Eriksons, Svenssons, Karlsons, and Petersons [*Electronics*, Aug. 17, 1970, p. 115].

Curiously enough, industry had no real objections to the law. In fact, computer specialists have been asking for years for a privacy law or

Backs privacy. Swedish Prime Minister Olof Palme's Social-Democratic government has pushed through the world's first national law protecting citizens' privacy from computers.

ground rules to be established before any public reaction against data banks could result from their abuse and reach a point that would affect computer development.

Broad coverage. The law will affect such data banks as payroll records, personnel lists, customer lists, subscriber lists, direct mail lists, credit rating lists, and, in a word, any register, handled by automatic data processing, in which an individual can be identified.

Jan Freese, deputy director-general of the board, says these range from the giant registers containing millions of names—like those kept by direct-mail firms or insurance companies—down to small company records. The smallest he saw had 27 names, in a company with a very complicated piece-work payment system. At this point, specialists involved with the law do not see that it will mean anything as far as hardware is involved. However, once the board starts to make specific rulings on cases, there could be demand for some hardware—such as additional memory capacity for logging transactions to provide a record of who gets what information, or for providing scrambling and descrambling equipment to insure privacy when filling board demands. Also, there could be additional work for programers, and computer service companies will be facing additional work to upgrade their customers' data banks to meet board requirements.

More to come. The only personal registers covered by the law are those set up for automatic data processing. The law does not cover manually operated systems—if there are any. However, another law that will be presented to parliament next year covers all— automatic or manual—credit rating reporting and personal filing systems. This law will have some tough restrictions—including the fact that only Swedish companies can provide such services. Thus, credit reporting will be covered by both the data bank law and the special credit law—when the systems are computer-based.

Sweden's law making all public records open to the public has meant that an individual knows what a state or municipal data bank contains on him. But until now he has had no control over private data banks. "What we have done is extend the principle of public information into the private sector, when it deals with personal information," says Freese.

One important section of the new law extends the rule of obligation to observe secrecy—a rule that applies to such professions as medicine, social work, and some government officials when they are concerned with personal information—to private data bank operators. If the board rules that a data bank operator must be silent, he is then covered by this ruling.

The director general of the Data Inspection Board is a jurist and career civil servant, Claes-Goeran Kaellner, who knows very little—if anything—about computer data banks. But the law requires that a majority of laymen make up the nine-man board, with only three experts. One is Aake Pernelid, managing director of the state computer consulting system (right now busy setting up an on-line system to link all pharmacies to a central computer). Another member is P. G. Vinge, a computer security specialist with the federation of Swedish industries, and former head of the Swedish counter-espionage service. Others are mainly parliament members from different parties.

America. What is the U. S. doing to protect the rights of individual citizens when it comes to government and private data banks? "Not much at all in the private sector since the Fair Credit Reporting Act," admits one congressional legal expert on the subject. And on the Government side, limits are still fuzzy on what the Department of Justice and its FBI can do with arrest records and other data in the National Crime Information Center.

Of the Fair Credit Reporting Act and its impact on private data banks, an attorney for the Senate Subcommittee on Constitutional Rights observes that individuals must take a positive action to exert their rights to notice, access, challenge, and correction of errors in private data banks—even those of some insurance companies.

But "the individual must know the record is being kept first before he can act," the lawyer points out, adding the situation is not much different than in Sweden. Usually, the requirement to notify an individual of the record is couched "in the most vague, broad, and nonhelpful language" that the record keepers can come up with. □

It's the law

While Sweden's new privacy law permits the Data Inspection board to act only as an adviser in the case of government data banks, it gives the board sweeping power over private installations. Here are the main points:

- A personal register (a data bank containing names or lists where an individual can be recognized) can be kept only with permission of the board.
- No information can be kept of highly personal, sensitive matters—such as data on a person's alcoholism, arrest record, psychiatric treatment—except with special permission from the board.
- No registration can be made of an individual's religious or political views (although parties or churches can keep membership lists).
- The board will rule on how each data bank can be set up and used.
- Each individual will have the right to get a free printout—in understandable form—of what a data bank contains on him.
- Anyone can sue a data bank if it spreads false information on him.
- An individual can demand (and get the board to enforce the demand) that corrections be made, or that his or her name be eliminated from a bank.
- Data banks cannot be moved outside the country without permission.
- Operators of data banks can be made to notify individuals that their names and other information are being kept in the register.
- Operators of such banks must make provision for logging of transactions, and must also provide any security systems that the board demands.
- Revisions in type or extent of material, and how a bank is used, can be made only with board permission.
- Penalties for violations can lead to a fine or maximum of a year in prison.

Military electronics

SAM-D hits a challenge

GAO questions planned procurement cuts, rising costs, technology of Raytheon's air-defense system for the Army

by Ray Connolly, Washington bureau manager

As the Congress weighs the Army's fiscal 1974 request for $194.2 million to continue development of its SAM-D ground-to-air missile-defense system—a 13% increase over the year before—the General Accounting Office has come up with a long list of challenges to the system's rising costs and its relative capabilities.

Though the Department of Defense has yet to make a public response to the 66-page assessment of SAM-D by the congressional auditors, the GAO's judgment that the Raytheon Co. program "exhibits many of the characteristics identifiable with problematic weapons systems in the past" is one that clearly upsets the decision makers in the military.

The GAO even takes aim at the Army's efforts to pare the program's costs by cutting back on planned procurement of SAM-D tactical fire sections by 68% and the number of missiles by 52%. Despite these cuts, the GAO's declassified version of the study says total program cost of $4.37 billion for the missile system is still up 9% from the 1967 development estimate.

Though the number of SAM-D units to be bought is classified, the

SAM-D

One SAM-D fire section with its 20 missiles comes closest to an 18-missile Hawk battery, although a SAM-D battery consists of two sections with 40 missiles. It takes three batteries to make up a SAM-D battalion.

The principal components of a SAM-D fire section are a fire-control group composed of radar van, power unit, weapons control unit with computer, and five launcher units with four missiles each. Additionally, there are support items for such purposes as maintenance, missile handling, and crew training.

The single SAM-D radar combines the functions of search, surveillance, missile acquisition, tracking and guidance, target illumination and tracking, and interrogation—friend-or-foe plus ECM sensing.

It is a phased-array unit and does not have 360° capability. Information on range, altitude, and multiple target capabilities are classified.

Each launcher unit carries its missile rounds in individual canisters that double as shipping containers and launch tubes. Launchers can be rotated through 180° by remote control from the weapons control unit to engage various targets.

SAM-D's missile is wingless and designed for boost glide with very high acceleration and speed similar to the Sprint antiballistic-missile system. The warhead of the missile in the SAM-D system contains high-explosive with a nuclear option, and maneuverability is provided by four rear-mounted fins.

SAM-D is hardened against electromagnetic pulses: Improved Hawk is not.

Improved Hawk

One Hawk battery has one pulse-acquisition radar and another improved continuous-wave-acquisition radar, each of which rotates continuously through 360°. Another range-only radar in the battery provides critical threat information under certain electronic counter-measure conditions.

Hawk's information-coordination central van houses the system's computer, communications, and interrogation—friend-or-foe hardware. The unit automatically assigns targets to each of the two fire sections after their acquisition. Another battery-control central unit provides tactical control of the battery and over each fire section and permits automatic, semi-automatic or manual operation by the crew.

A guidance-illuminator radar in each fire section—part of Improved Hawk's guidance group—reacquires, tracks, and provides a reference signal to the missile. It accomplishes this by target data from the information-coordination central unit.

As for launchers, each Hawk fire section has three, armed with three missiles each. The launcher designated to fire activates and aims a missile and then launches it. A tracked loader vehicle in each section then reloads a launcher, whereas Raytheon's SAM-D missile-launching system uses a crane.

Additionally, the Improved Hawk's ground support equipment contains built-in test equipment. Just as for the SAM-D, each Hawk missile is a certified round that is designed to require no field testing or maintenance once it leaves the factory.

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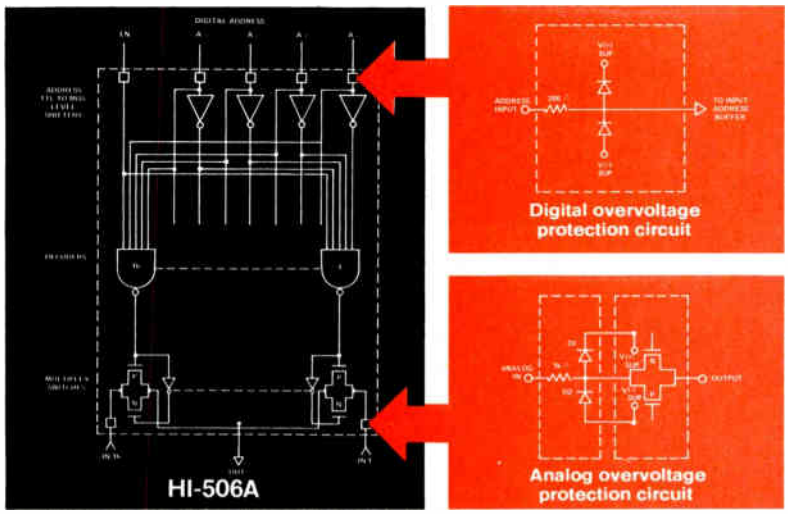

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GAO says unit cost tripled. Of that increase, says the Army, more than a third (42%) is attributable to cost escalation, 27% to the reduction in quantities to be bought, and 31% to correction of prior estimating errors and engineering and schedule changes.

Army disagrees. Cuts in proposed SAM-D procurements, while acknowledged by the Army, are "certainly not as severe as GAO makes them out to be," says one official. "They're going back to a 1967 development plan for a base when SAM-D was a different system. They're comparing apples with oranges." Admittedly, SAM-D was configured differently six years ago, with batteries generally envisioned as much more complex. They had four firing sections then, rather than two, with each section having two launcher groups and one launcher control group.

Each section would have had its own radar and limited computer capability, making four radars per battery, rather than one now. With six missiles to a launcher, rather than the four now proposed, there would have been 48 missiles to a battery, instead of 40.

But the biggest difference between 1967 and 1973, in the Army's view, is that SAM-D is not proposed for use in the continental U.S. "That was decided a long time ago, and the GAO knows that it was," says the Army's advocate. "By cutting out CONUS, you cut out quite a bit," he points out.

Contrast. Ironically, the congressional investigators use another Raytheon Co. system—the Improved Hawk, which SAM-D is designed to replace—as a means of pointing out some of SAM-D's limitations. For example, it notes that a single Improved Hawk rotating radar can scan a greater area than SAM-D's fixed, phased-array unit. Moreover, a Hawk battery's two radars will permit it to function with a limited capability if one is lost; the loss of SAM-D's single radar will put a unit out of action. Balanced against this is SAM-D's longer range, and multiple-target-tracking and multiple-missile-guidance capability compared with Hawk's ability to take on targets at the same altitude only one at a time.

Similarly, the GAO wonders whether SAM-D's greater engagement and faster firing rate is offset by its "significantly longer" reloading time when compared with Improved Hawk.

Though SAM-D has 40 missiles to a battery of two fire sections compared with Hawk's 18 per battery, the GAO notes that Hawk is less vulnerable than SAM-D to a follow-on attack after all ready missiles have been fired. Precise reloading times for the two systems are classified by the Pentagon, but the report indicates that SAM-D cannot be reloaded in less than 30 minutes.

Cutting down personnel. At a time when the Army is trying to get along with fewer personnel without diminishing force effectiveness, SAM-D's ability to use some 7,500 fewer people following replacement of Improved Hawk and the older Nike-Hercules batteries has been emphasized by the service. Yet the DOD Development Concept Paper No. 50 on the new system notes that "replenishment spares and maintenance and overhead costs" of SAM-D "will cause operating costs per battery to be greater than Improved Hawk, offsetting the cost advantage of fewer personnel."

Using the concept paper's estimates, the GAO figures that the 10-year life-cycle cost for a SAM-D battery would be $102 million compared to $43 million for an Improved Hawk.

Another point made by the GAO—that the Army deferred testing of critical components, notably the guidance and warhead-fuzing subsystems, based on an approval of the Director of Defense Research and Engineering—is challenged by Army officials.

The GAO notes that the DDR&E approval was based on "the fact that delays had occurred in the program plan due principally to funding shortages" and that "these delays resulted in a less mature design model available for testing."

The Army notes that the tests were deferred because the $35 million cost forecast to test 10 vehicles would not have been beneficial for two reasons. "First, these would have been handmade jobs—not what we are building and using now. And, second, by captive flight testing of components" using aircraft to test and stress breadboarded hardware that was headed for the SAM-D missile, "we had already learned a lot. We would not have gained $35 million worth of data from those tests."

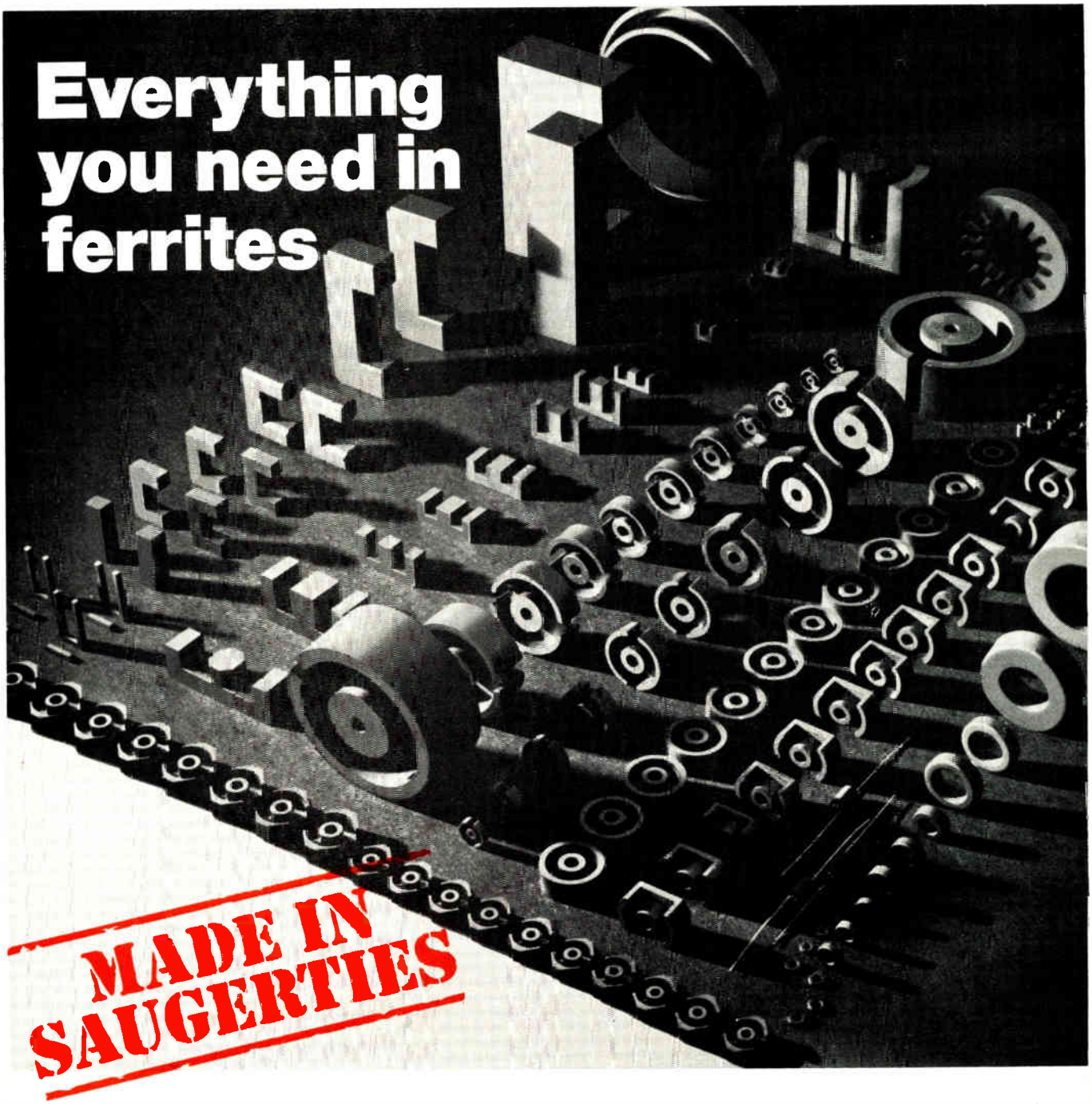
Technology. A key issue in the deferred testing is SAM-D's track-via-missile guidance system. "TVM guidance was planned for the Navy's Typhoon system which was canceled in 1964," says GAO, and "was again considered, but rejected, for the Navy's Aegis missile system after being assessed as a high-risk element and not necessary for an antiaircraft weapon." As a new technique, TVM poses two problems:

- How to direct the missile's nose antenna at the target while at the same time keeping the rear antenna oriented to the ground radar.
- The complexity of its data and command links.

The GAO contends that the guidance system "has no operational precedent" and considers it to be "potentially problematic." As for the warhead-fuzing interface, the auditors note that it is not scheduled to begin flight testing until 1974.

The Army, which says it has rebutted the GAO criticisms point by point in a confidential response, indicates it sees no imminent threat to its SAM-D effort from the analysis of the system. In fact, says one source, questions raised in the study were available to congressional committees before the GAO report was generally available, and these questions were answered in Army testimony on the fiscal 1974 budget.

Does Europe need it? Nevertheless, one politically imponderable threat to SAM-D's long-term potential—particularly when a production decision is still some years away—was raised to the Congress by the GAO. It is the issue of whether SAM-D will be needed for defense of continental Europe where deployment is planned. Should the U.S. and its NATO allies successfully negotiate a reduction in forces with the Warsaw Pact countries, notes the GAO, this could "impact significantly on the quantities of SAM-D fire sections" there. □



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16402

Military electronics

Navy eyes two Sanguine sites

Geologically acceptable areas in both Texas and Michigan may be used in plan for extremely-low-frequency command system for submarines

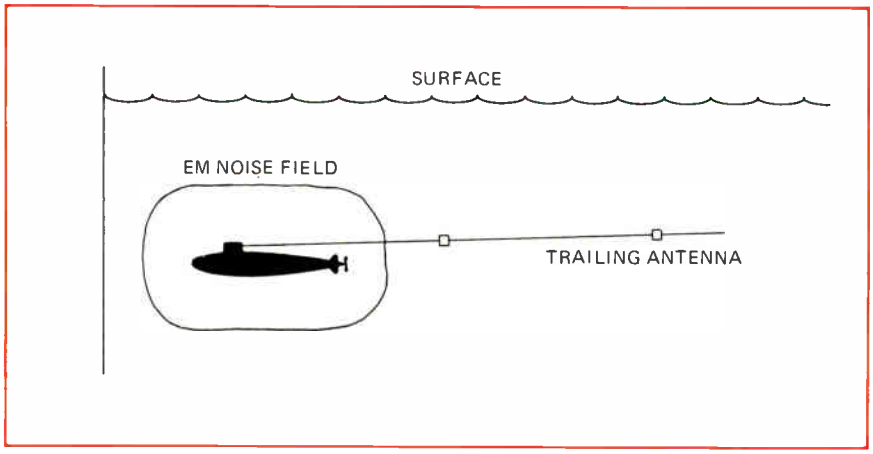
by Ray Connolly, Washington bureau manager

The Navy is considering the possibility of two continental U.S. installations for Project Sanguine, its extremely-low-frequency (ELF) transmission system designed to order fleet ballistic-missile submarines on patrol to launch their weapons following an attack on the United States. This was indicated by one Naval Electronics System Command official in Washington, who noted that the command could proceed with "parallel" development awards to two contractors in late 1974 following completion and evaluation of Sanguine design validation proposals next spring. Contractors for that first phase include GTE Sylvania, RCA, and TRW Systems (see p. 38).

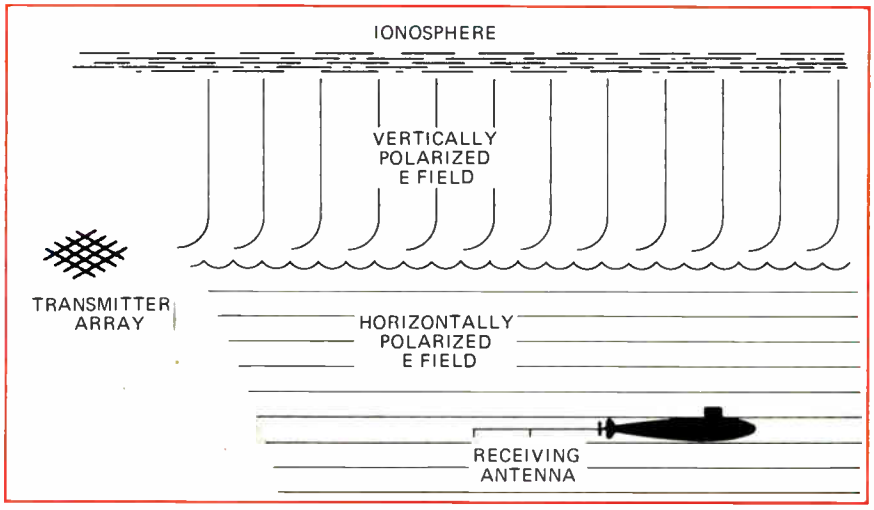
In the event of a decision to proceed with more than one transmitter, the Navy probably would use both sites: its preferred location for installation of the Sanguine grid atop the nonconductive rock formation known as the Llano Uplift some 45 miles northwest of Austin, Texas, as well as an alternate one in the upper Michigan peninsula where the bedrock is part of the Laurentian shield. Indications are that two relatively low-cost installations would employ slightly different technologies to guarantee the Sanguine system's security by reducing its vulnerability to attack and to electromagnetic jamming.

Specs. How the Sanguine system would work has been detailed in a technical overview by Bodo Kruger of the Navelex special communications project office. Kruger's report notes that Sanguine's command, control, and communications mission calls for a system in the ELF band of 30 to 100 hertz with "the most likely carrier frequency being 45 or 75 Hz." Though Sanguine is proposed for use in "pre-, trans-, and post-attack conditions" carrying "high-priority operational messages," officials acknowledge its principal function would be to deliver missile launch commands to American submarines dispersed around the world after an attack on the U. S.

At the least, such a system must be able to "deliver the messages in a specified time; survive conventional and nuclear attack; survive the electromagnetic pulse from low- and high-altitude nuclear bursts; be resistant to attack on the propagation path, and resistant to electromagnetic attack or jamming. Additionally, the National Command Authority has specified that San-



Undersea signal. Since ELF is less subject than higher frequencies to interference, one buried transmitter array can send a virtually unjammable low-data-rate signal to submarines.



guine have a survivable interface with NCA injection links, permitting injection of its message into the transmitter.

Though the range of a system operating at 75 Hz is about 2,500 miles, practical ELF transmitting antennas have relatively low efficiencies—approximately 10^{-4}—because they are electrically short. As low ground conductivity is critical, the Navy must bury its ELF grid atop a rock shelf such as those that exist in Texas, Michigan, Wisconsin, and a handful of other continental sites that have been surveyed.

Product must be right. Moreover, to radiate the required power, the system must be sized for the right product of the antenna current (amperes) and total antenna length (meters). Proposed Sanguine systems have a product on the order of 10^7 to 10^8 ampere-meters.

Proposed Sanguine transmitter grids now range from 40 by 40 to 80 by 80 miles on a side with cables buried 6 feet deep. Total amplifier output is on the order of 10 megawatts, although maintenance of a secure system calls for use of more than 100 power amplifiers of about 100 kilowatts each distributed throughout the system.

"Preattack, the amplifiers will be fed from commercial 60 Hz power systems," according to a study made by Navelex. "Post-attack, the amplifiers will be fed from emergency power supplies that will have the same survivability as the amplifiers." Amplifiers using tubes or solid-state devices are both possibilities.

In terms of signal design, the Navy's goals are extremely low error rates at the lowest possible signal-to-noise ratio, signal spreading over the available antenna bandwidth to improve antijamming capability without increasing power, and optimization of the received signal-to-noise ratio to minimize receiver bandwidth.

To meet the first goal, message compression and formatting will be employed before messages are digitized and coded. Convolutional coding, the optimum within the state of the art, will be used to ensure the

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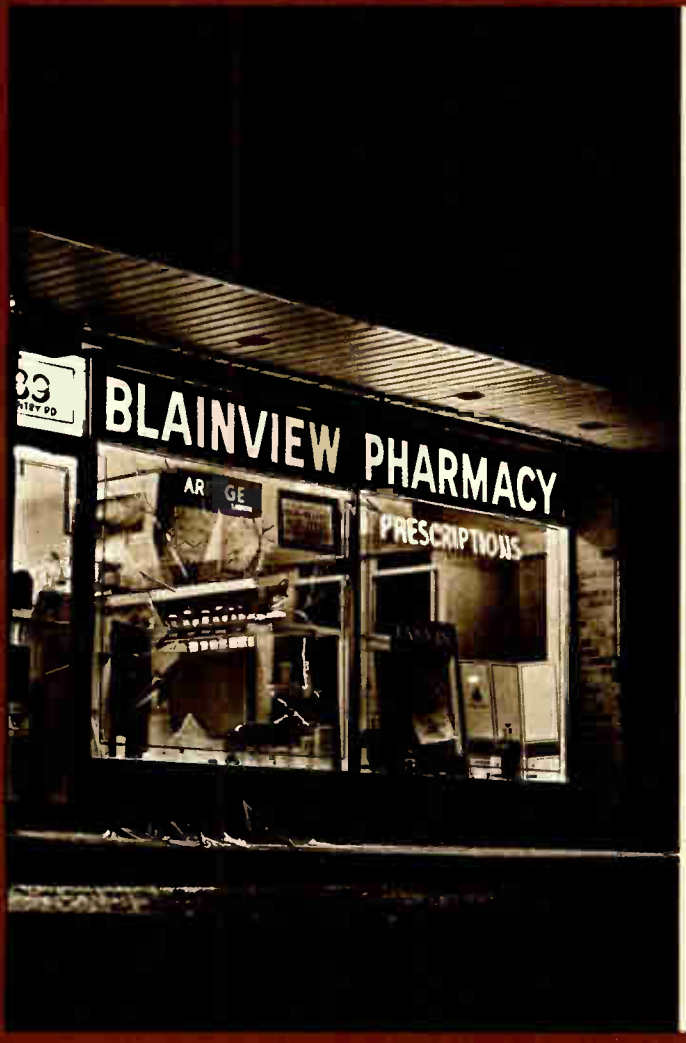

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low error rates for Sanguine. As for minimizing receiver bandwidth, the Navy says it can be obtained by the choice of minimum shift keying for the transmitter. "MSK is a form of angular modulation which gives a near-optimum bandwidth and which can be implemented in hardware," according to the study by Navelex.

Because of Sanguine's modest data rate, most of the receiver functions can be implemented on a small digital computer, typically a machine with an access time of 1 microsecond and a 16-kilobit memory. The receiver will use nonlinear signal processing to cut atmospheric noise, while coherent demodulation is achieved by means of a stable clock. "At extremely low frequencies, the stability requirements of the clock are modest and well within that state of the art," according to the Navy.

To get what have been called "Sanguine's doomsday signals" into a submerged missile-carrying submarine's receiver, the Navy is contemplating long-trailing wire antennas to overcome the galvanic electromagnetic noise field generated by the boat itself.

Since the Sanguine transmitting system will be "more than 10 times as expensive as all the planned or potential receivers for the U.S. forces," the Navy points out that economy dictates that the signal's depth capability be achieved "by low-noise antenna design, rather than by oversizing the transmitter."

"The most successful design is the trailing E-field antenna," according to Navelex. Trailed behind the boat's noise field, it is bidirectional and consists of two electrodes which sense the E-field in the water. The antenna is terminated by a tail which damps out vibrations of the last electrode.

However, if the null of the antenna's figure-eight pattern is pointed toward the transmitter, no signal will be received.

Together. Another possibility is the use of a combined E-field and H-field antenna, since the H-field antenna, with its long helical sensor winding, produces a bidirectional figure-eight pattern that is perpendicular to that of the E-field antenna. If the two antenna systems are combined with suitable phasing into a single unit, an omnidirectional pattern can be achieved.

What pleases the Navy about Sanguine is that it "cannot be jammed completely. Only the message delivery time can be increased at a very high cost to the enemy." Not only would a jammer require several times the radiated power of the Sanguine transmitter before it could significantly increase message delivery time, but two jammers would be required to affect all operational areas.

Should the Navy proceed with its plan for two Sanguine transmitters, the odds against jamming become insurmountable. □

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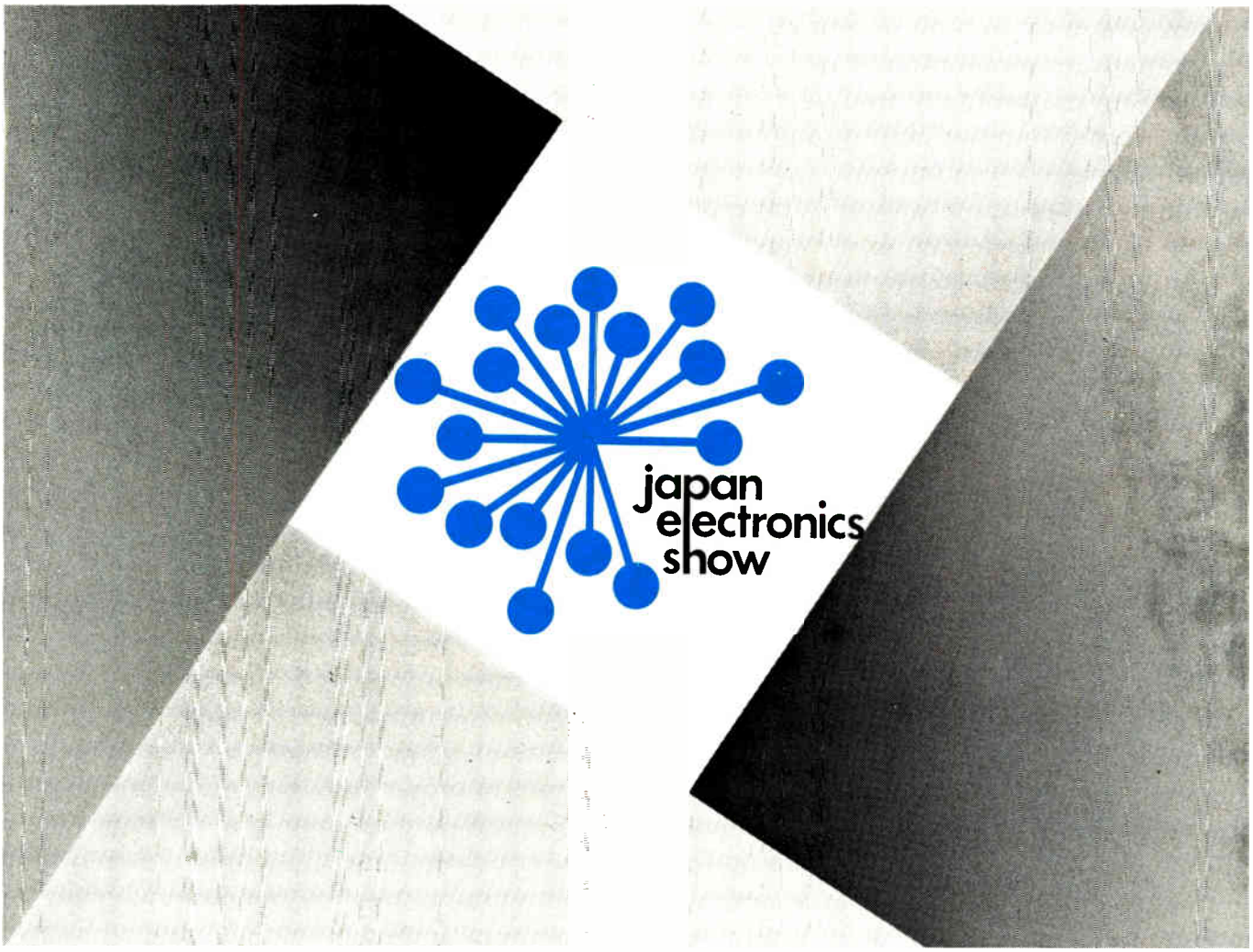

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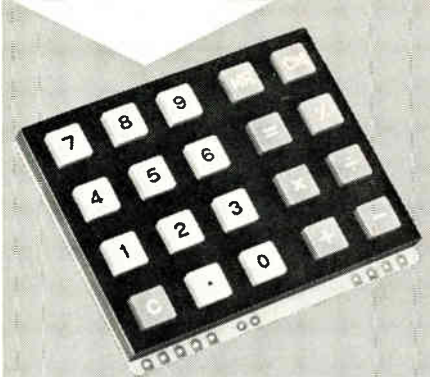

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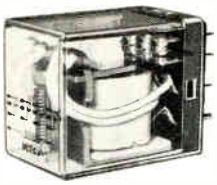

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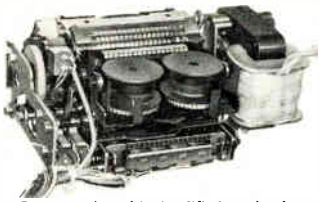

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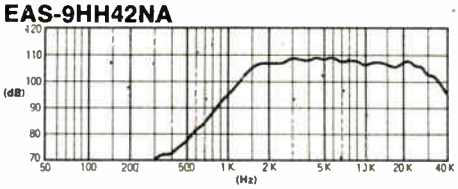

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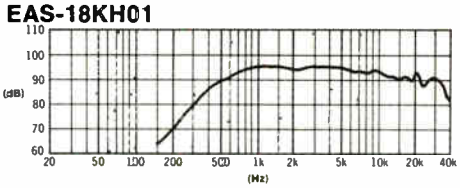

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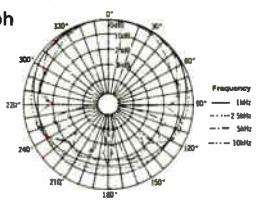

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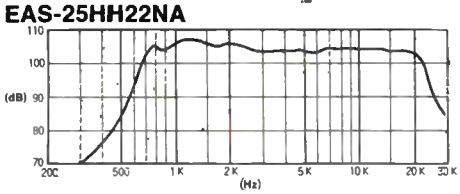

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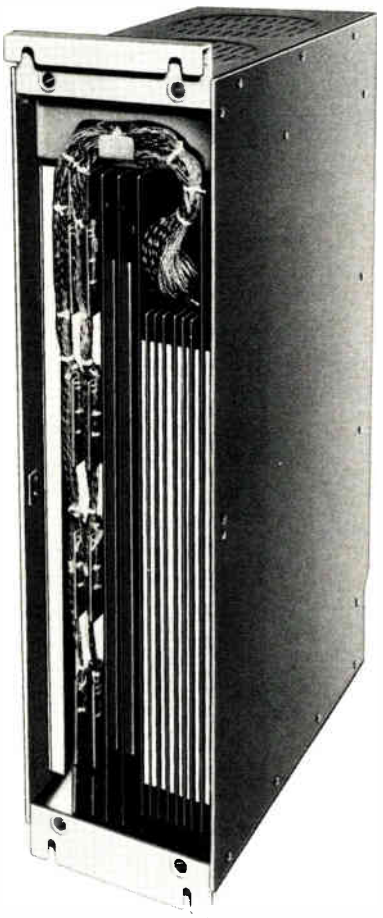

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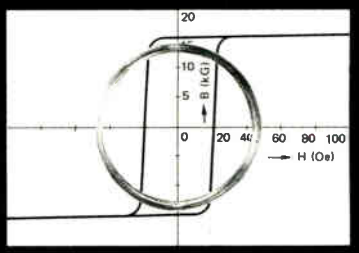

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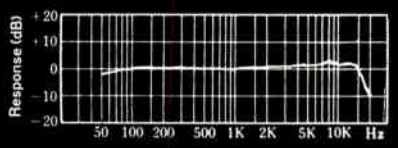

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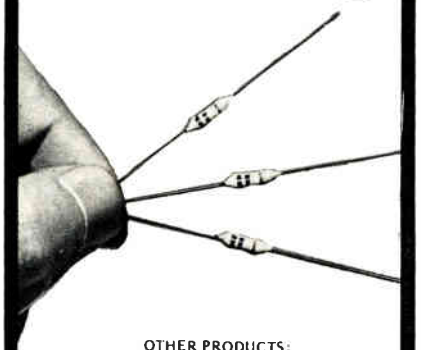

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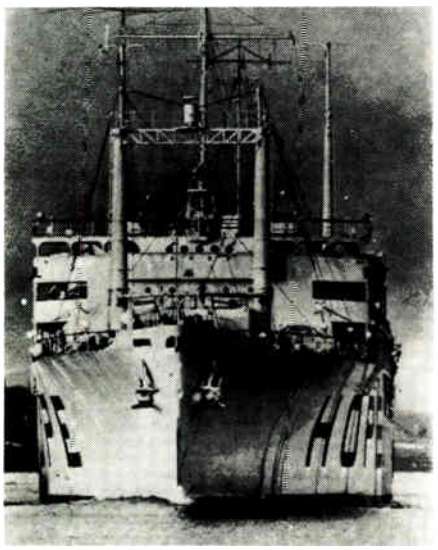

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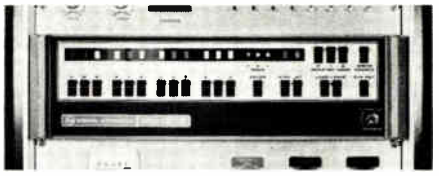

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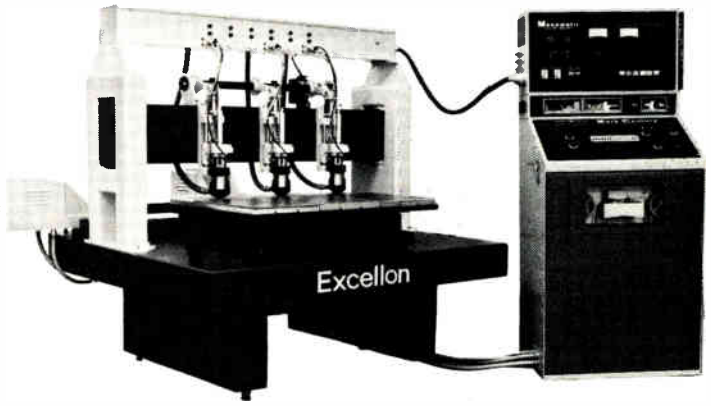

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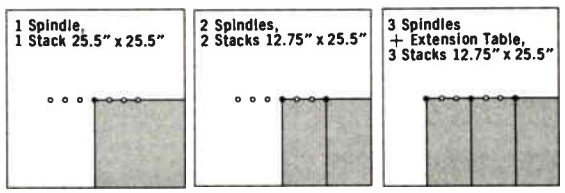

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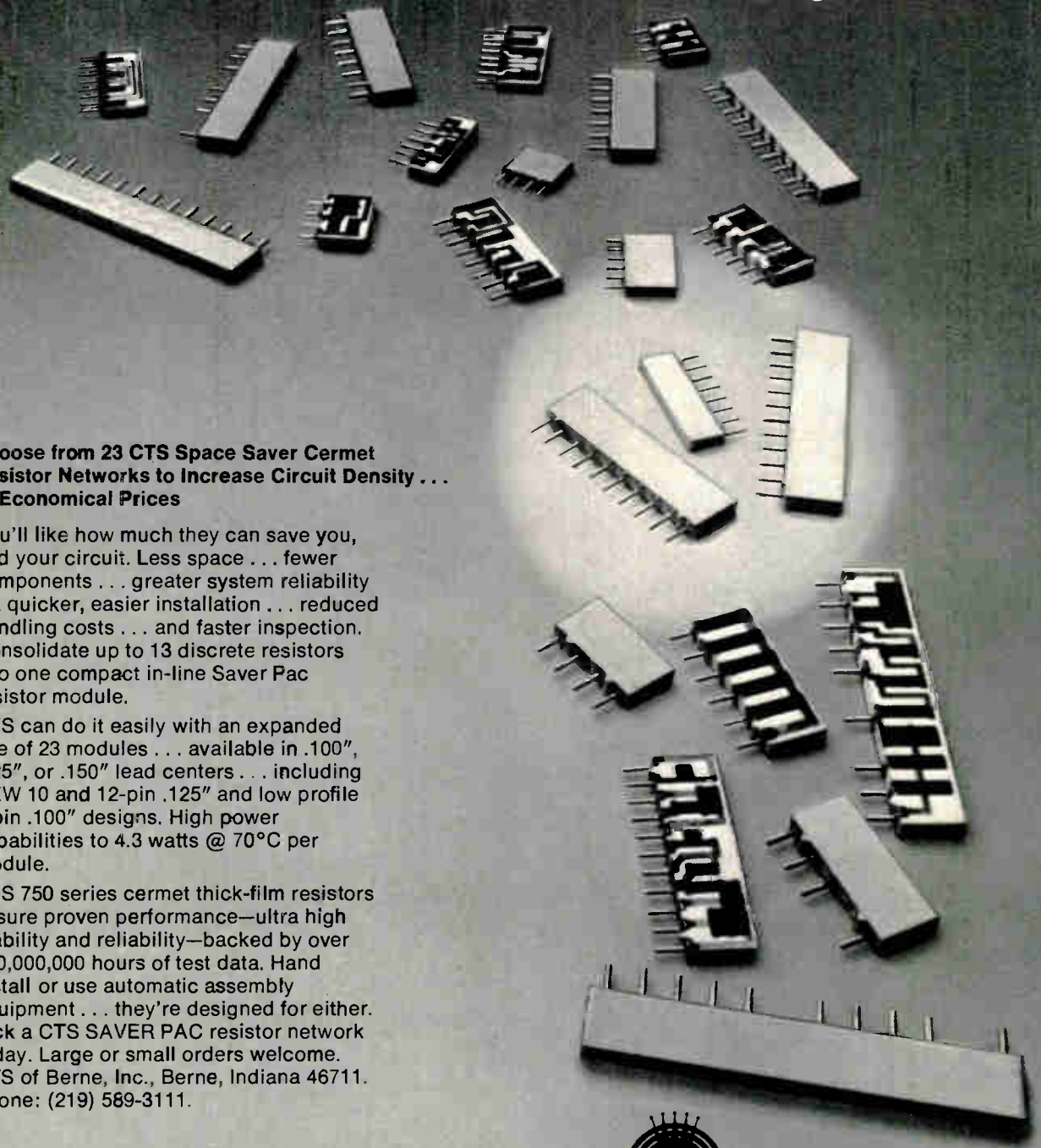

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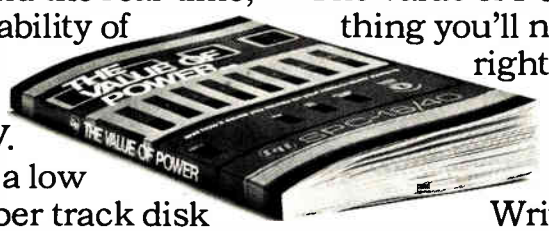

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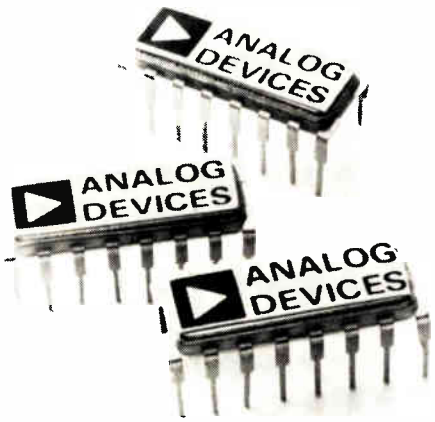

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Robots handling more jobs on industrial assembly lines

Although the market optimism of the 1960s has proved premature, increasing numbers of manufacturers throughout the world are building automatic manipulators to handle boring and dangerous factory tasks

by Alfred Rosenblatt, *Industrial Editor*

☐ Set against the lofty sales peaks predicted in the mid-1960s by their developers, the industrial robot can be rated a disappointment. But while sales have lagged, the field has been extremely active, and the number of companies producing programable materials handlers has dramatically increased. Designs have been modified as technology—primarily electronics technology—has advanced. And the minicomputer, with its promise of controlling groups of robots from a central point, has arrived on the scene as it has in so many other industrial areas.

But perhaps most important, the robot, little more than a pivoted arm with a hand-like gripper at one end, has been applied to an ever greater variety of tasks and machines. Early applications in relieving human operators from dull and even dangerous tasks associated with such things as die casting and forging machines have been expanded to include painting, welding, processing dangerous explosives, handling glass and ceramics, palletizing bricks, and loading and unloading machine tools. Furthermore, the tireless robot increases productivity.

As for the market, sales of robots in 1972 are estimated by Joseph F. Engelberger, president of Unimation, Inc., to have been in the range of $12 million to $15 million and growing at a yearly rate as high as 35%. In the main, however, manufacturers are no longer willing to go out on a limb with glorious sales predictions as they did after robots were first introduced. Six years ago, for instance, Engelberger was looking forward to 5,000 robots in use by 1972 [*Electronics*, March 20, 1967, p. 165]. And then president of AMF Versatran, Samuel Z. Shoshan, was predicting 50,000 of the mechanical helpmates by 1980.

"Any number I give would be wrong," laughingly declares E.J. Van Horne, general manager of the AMF Versatran division, Warren, Mich. "It's certainly a growing market now, and the most significant thing is we're getting third and fourth orders from the same customer."

Electronic content lags

The use of electronics in robots has varied throughout the world, but the systems generally rely on components no more sophisticated than potentiometers, programing

Safety first. Unimate robot feeds parts from a conveyor belt into dies of 2,000-ton stamping press, a hazardous job for a human operator.

panels, and relays. But robots controlled by minicomputers are under development by manufacturers in the U.S., Sweden, England, and Japan. And in the research laboratories, robots with sophisticated sensors and guidance equipment are being developed.

For equipment going to the field, electronics costs could be coming down. Unimation's Engelberger says that 12 years ago, the electronic portion of his Unimate robot represented 75% of the total cost; today it's down to 35%. And he says, "I believe that the way costs are going, compared to the cost of the mechanical structure, I'll soon almost be able to give away the electronic controls."

Extensive use of robots in manufacturing has been virtually mandated by new Federal safety regulations under the 1970 Occupational Safety and Health Act (OSHA), which takes effect in 1974. Instead of human operators, robots will have to do such jobs as loading punch and stamping presses—tasks in which a human operator runs the high risk of losing a limb.

Both industry and labor around the world seem to be welcoming the advent of the robots, and endorsements by industrial leaders are bound to stimulate sales to come. For example, officials of General Motors Corp., probably the largest user, are pleased with the results. At one installation—the Lordstown, Ohio, assembly division—GM is using 26 Unimates from Unimation to put about 390 spot welds into its Vega automobile. And Ford Motor Co. has a similar type of Unimate-equipped welding line just now going on-stream for autos and small trucks. In Europe, Fiat and Daimler-Benz are also using robot-equipped assembly lines. Actually, the automotive field and its broad base of suppliers probably has more robots in operation in its production facilities than any other industry.

Labor is receptive

As for U.S. labor, the United Auto Workers welcomes the robots, so long as the men that they displace are guaranteed jobs elsewhere. Union officials realize that members will profit from increases in productivity. Robots have been well accepted by workers in Europe, as well. In Sweden, especially, unions and workers have long been receptive to automation because the government steers displaced workers to new jobs that are opened up by advancing technology. Manufacturers have difficulty finding workers for monotonous, boring jobs, and wages in Sweden are the highest in Europe.

In Japan, long noted for cheap labor, that labor is no longer so cheap. Revaluations of the dollar and large pay increases during the past few years have taken care of that. In addition, there is an increasing reluctance on the part of most workers to remain at jobs in uncomfortable surroundings where the environment is hot, dusty, or otherwise unpleasant or dangerous. This is true, of course, not only in Japan, but in other countries as well.

Altogether, more than 140 companies are said to be building some 180 models of robots throughout the world, an amazingly large figure, in view of the relatively small number being applied. Incidentally, many companies now selling robots built them initially to automate their own production lines. Most of the companies in the field—as many as 100—are in Japan, with

What's in a robot?

Far from being a mechanical man—a "Robbie the Robot" with quasi-human qualities—an industrial robot is actually little more than a mobile arm, attached to a chunky box and ending in some kind of grip. In fact, says E. J. Van Horne, general manager of the AMF Versatran division, Warren, Mich., "A robot is what your kids watch on 'Lost in Space' on television—the devices we build are so much simpler that we prefer the term 'programable manipulator.' "

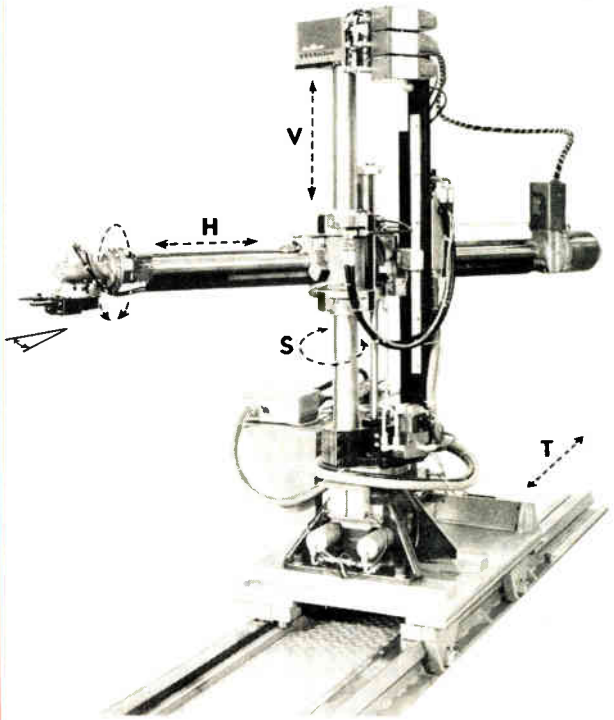
Under either name, the devices may look like anything from a Sherman tank turret (Unimation Inc.'s Unimate) to an assembly of telescoping pipes (the Autoplace robot). The manipulators are designed to do simple, repetitive tasks, often in circumstances that would endanger or kill human operators. For instance, they may handle parts that are red-hot or icy cold, in poisonous, corrosive, or dusty atmospheres, or they may operate in conjunction with other machines, such as a punch press or stamping mill, that could injure a careless operator.

Like numerically controlled machine tools, industrial robots may operate either point to point or follow continuous paths. A point-to-point robot will move a part in the most direct path from one production point to the next—perhaps transferring a finished part from a die-casting machine to a moving conveyor belt. Its positioning accuracy can be as fine as a couple of mils. A continuous-path robot must, on the other hand, follow a specific contour because it performs its task as it moves—perhaps spraying enamel on bathroom products.

Most robots are capable of interacting with and even controlling the machines with which they operate. For example, a stamping machine may signal the robot that it has stamped out a part. This signal prompts the robot to remove the part and, in turn, signal the machine to stamp out the next part. Then it places the stamped part at the next work point and signals the machine there to start its operating cycle. A single robot, if it's large and sophisticated enough, may even be programed to reach in and serve two or three and possibly more tools.

The hand at the end of the robot's arm consists of finger-like clamping devices for holding onto parts and as-

In motion. Versatran manipulator, its protective housing removed, models the motion axes typical of industrial robots.



semblies. It may incorporate single or double sets of fingers, or may have vacuum or magnetic pickups for handling flat sheets of glass or metal. Often, the robot is designed so that different hands may be attached for different applications. And this can even be done automatically rather than by a human operator.

The robot manipulators possess varying degrees of freedom, depending upon their design. A robot arm may be able to move vertically and horizontally or to rotate its hand, or grip. The hand itself, besides opening and closing, will rotate, yaw, and pitch as if it had a wrist. In addition, some robots, like Versatran, have still another axis of motion—mounted on tracks, instead of on a fixed base, they can position themselves at points along the tracks. The result is that robots move in as few as two axes or as many as five or six and, depending upon how the manufacturer defines them, even eight.

The control part of the robot system consists of at least three basic elements—an actuating source of energy, some kind of memory, and a programer that sets the proper sequences.

The actuator moves the arm from place to place. It may be pneumatic, as in the Auto-Place robot, which makes use of the high-pressure air found in many machine shops. If electro-hydraulic, as in the Unimate and Versatran robots, it is capable of more power than a pneumatic system and, because it is "stiffer" and can be under servo control, it has generally greater repeatable accuracies. Finally, some of the newer robots such as the minicomputer-controlled robot developed by Sundstrand Corp., use electric motors with gearing to reduce the motor speed and increase torque (an all-electric design, though slower, is said to require less maintenance because it has no hydraulic or pneumatic valves and produces less noise and smoother movements with less overshoot than the others).

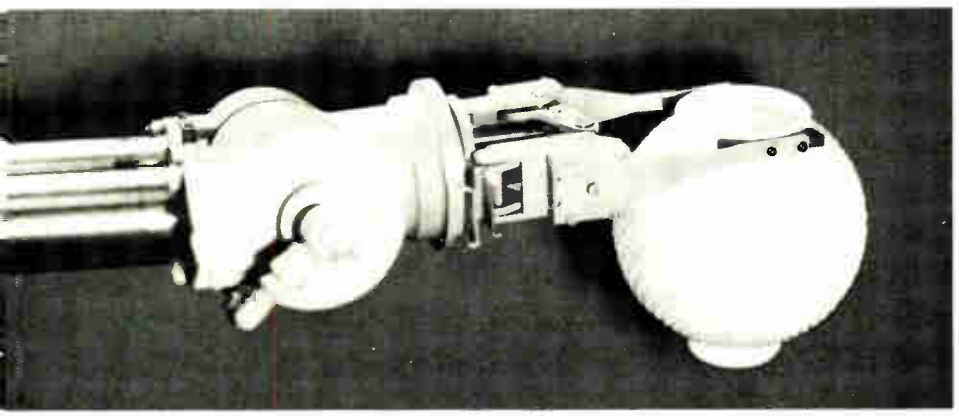
In moving to a position the robot arm may be under open-loop or, in the more sophisticated units, closed-loop servo control.

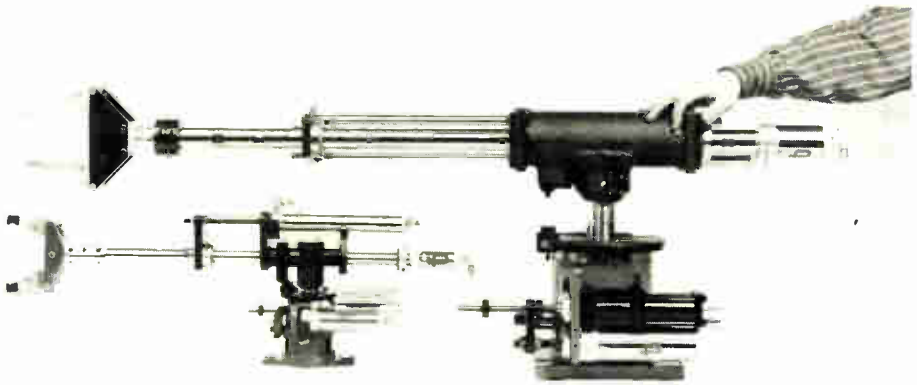
To keep track of the positions to which the arm must move, the robot also must have some sort of memory—a rotating magnetic drum, the plated-wire memory of the Unimate, potentiometers, as in the Versatran or Liberator machines, or the MOS shift registers of a new control system from Sweden's Retab. In addition, there are the solid-state memories associated with minicomputers used in Sundstrand Corp.'s robot, or the minicomputer-directed machine built around a Unimate by Japan's Kawasaki Corp.

Also to be counted under the memory classification are the simple limit switches and preset mechanical stops of most of the lower-priced robots. The robot merely moves in a direction until it clanks up against a mechanical stop, whereupon actuating power is turned off.

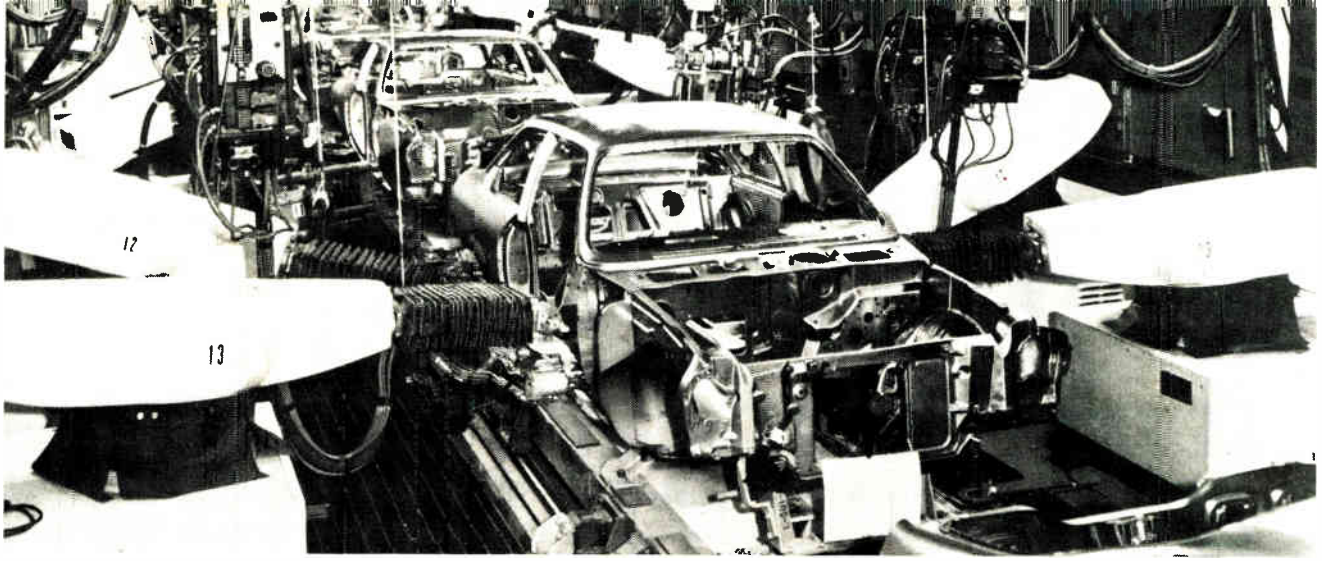
Finally, there is a programing section that directs the robot through its sequence of motions and the functions that are to be performed at each stop. In a minicomputer-directed system this, together with memory, is handled in the mini. In the Unimate, solid-state logic reads information off the plated-wire memory. In the Versatran and many other robots, pins stuck into an electronic patch or matrix board, which is then interfaced with relay or IC logic, fix the sequence of operations.

Actually, there is no shortage of suitable electronics (or electrical) hardware to function as amplifiers, memory, comparators, relays, analog-to-digital converters, encoders, and so on, in robots. The only problem is to make reasonably economic choices.





Variety. Types of robots run gamut from Sundstrand minicomputer-controlled unit (below), still in development, to the pneumatically actuated and controlled Auto-Place (below left) that uses hardly any electronics at all. But their touch can be as gentle as that required to lift a glass lamp cover.



Cluster. Spot-welding on General Motors' Chevrolet Vega line is handled by 26 Unimates, probably the largest single robot installation in the world. Reliability of the mechanical welders is as good "as any form of automation equipment," says a GM spokesman.

about 20 each in the United States and Europe.

Worldwide, some 2,600 robots, many simple and unsophisticated, are now operating—1,500 in Japan, 800 in the United States, and 300 in Europe, estimates Xavier B. Ghali, president of Robotronics & Technics Ltd., a consultant firm in Aarau, Switzerland.

In Europe, Scandinavia leads in robot manufacture and applications, but a large portion of the installed units are of American design. Elsewhere, robots are beginning to appear on production lines throughout Western Europe and even in the Eastern Bloc.

Prompted by both the needs of its industry and the stated goal of its government, Japan devotes more effort than any other country to the development of robot technology. And even the Japanese Diet has gone on record as desiring that the total domestic robot market grow by 1977 to $384 million, up from an effort valued at $27 million in 1972 and $38 million this year. If these government figures are valid, they dwarf the market estimates of the rest of the world.

In Japan, a declared government objective can be a substantial incentive indeed. But it is through industry working on its own, rather than by substantial government grants, that the Japanese hope to meet their goals. Three years ago, the Japan Industrial Robot Association was formed, and it now has 44 members, who read like a "Who's Who" of the nation's industrial might. A similar group in the United States is now being formed.

Interest is high

At present, interest in the fabrication and application of robots has never been greater. No longer are robots being promoted alone by such technological innovators as Unimation Inc., Danbury, Conn., and AMF Versatran. These two companies, virtually unknown at the time, first introduced sophisticated programable robots in the early 1960s and tried to sell them to skeptical industries.

Now, builders of factory-production-line machines are also investigating the feasibility of bringing their own robots to market. Among them are such machine-tool builders as Cincinnati Milacron Inc., which designs numerical-control equipment, as well.

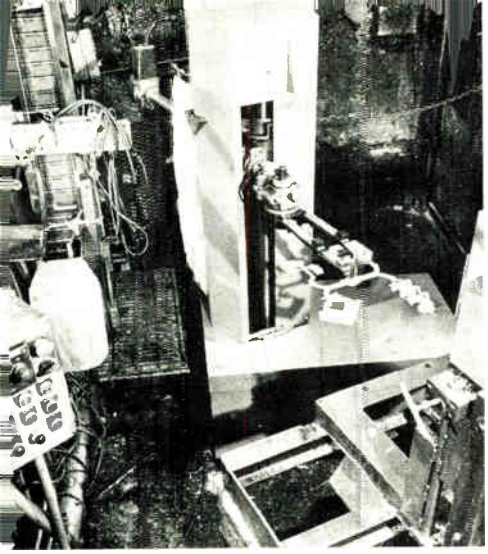
A Cincinnati Milacron spokesman would not deny the rumors nor would he comment regarding the company's plans. But Richard Phelan of the market research firm of Theta Technology Corp., Wethersfield, Conn., points out that robots could easily tend the large machining centers that operate with frequent tool changes. The numerically controlled automatic changing gear being used is bulky and expensive, Phelan continues, and an agile industrial robot could easily handle the changing chores, as well as do other work requiring human operators. Thus, the robot might handle raw stock, palletize finished parts, and even clean the jigs and sweep up shavings. Reprograming the robot might also be an easier task than modifying the control program of the machining center, Phelan adds.

Also interested in robots is computer-industry giant IBM Corp., Armonk, N.Y., which introduced a programable manipulating device a year or so ago but has withdrawn it from the market. However, IBM is reported to be still working with robots, probably next-generation units having tactile or visual capability.

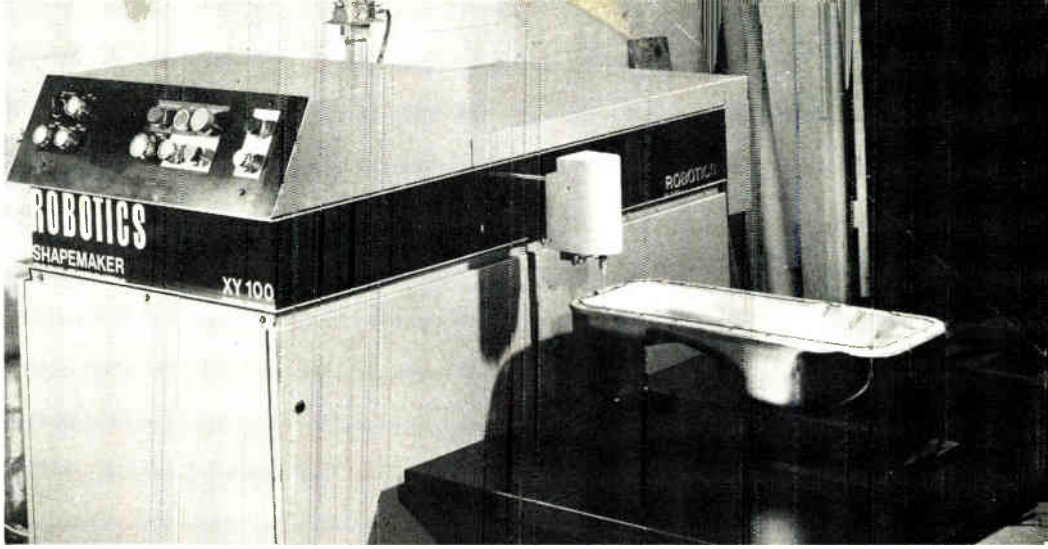
Still another manufacturer that's developed its own robot is USM Corp.'s Industrial Machinery group, Beverly, Mass., a producer of component-insertion machines for the electronics industry and automation gear for the apparel field. The company's new "small-parts manipulator." which is still being tested, will be a separate product line, says director of marketing Edward V. Manning. However, eventually the robot might be applied to tending the component-insertion gear. The entry into the robot field of such giant enterprises as USM, which last year grossed $527 million, IBM, and Cincinnati Milacron is likely to have a heavy impact on the industry.

Robots differ greatly

As with most products, industrial robots run the gamut from simple and low-priced to sophisticated and expensive. They may have anywhere from two to six axes of motion, or more, depending on how they're defined. The simple ones are pick-and-place devices, limited in the amount of weight they can lift and the numbers of steps they can be programed to perform. Some have, in fact, been around for decades.



Service. Versatran moves from die caster (left) to trimmer (right).



New way. Robotics Inc.'s programable ShapeMaker may make feasible a new production technique for laying down automobile gaskets in liquid or paste form.

"The cost of building equipment to orient the part often exceeds the cost of the robot, so the human feeds the robot which feeds the press or whatever equipment it operates with," points out research engineer D.W. Hanify of Illinois Institute of Technology Research Institute, Chicago. Prices may run as low as $3,200 for a pneumatically actuated and controlled Auto-Place manipulator from Auto-Place Corp., Troy, Mich., to a more complex $10,000-plus Syncro-Trans from Syncro-Trans Corp., Warren, Mich.

"Greater flexibility" describes how the so-called sophisticated robots differ from their simpler cousins. The sophisticates perform a much greater variety of tasks because they can be programed to stop repetitively at one or two orders of magnitude in excess of the 20 or 30 points the simple robots handle. They're also relatively easy to program by a "teach" mode in which the robot is first moved by an operator through its paces. Positions and functions are stored in a memory, which, in turn, is used to put the robot through its sequences.

These robots are also more sophisticated technologically, employing such devices as closed servo loop, rather than open loop, control of arm and hand actions, analog and digital memories, and minicomputers. They also generally lift more weight than the simpler units, and they cost more.

For example, the Versatran from AMF can lift up to 150 pounds, and it ranges upward in price from $14,000. The Unimate from Unimation comes in the 150-pound series 2000, which begins at $18,000, and the 300-pound series 4000, which may have a total system cost of $45,000. The gear required to interface the robot with the equipment it serves, as well as special tooling for the arm and hand, help bring the price up. Also in the higher-price class—upwards of $25,000—are robots that move in a continuously controlled, rather than point-to-point, paths. Both of these types of motion are, of course, analogous to the movements possible with numerically controlled machine tools.

It is notable that today's industrial robots doing useful work on the production line do not have any sort of visual or tactile senses. Although these "next-generation" characteristics have been promised for robots virtually since their birth, these developments are still to be found only at research laboratories and so-called artificial-intelligence laboratories. There, the problems of eyesight, hand/eye coordination, adaptive learning, and even judgment are being investigated.

Hence, the introduction of such characteristics to the production line would signal the coming of the "second-industrial revolution," the term of consultant Leo C. Driscoll, of Driscoll Associates Inc., Beverly, Mass. However, others, especially Unimation's Engelberger, believe the robots can do quite well without them. But, whether because of cost or problems of design, "the robots that will be built and installed in the 1970s are not likely to boast such esoteric capabilities," predict researchers Hanify and K.G. Johnson of IITRI.

Basically, programable robots have remained unchanged in their functional characteristics since they were first introduced a decade or so ago. However, the electronic hardware has, at least in one case, "changed radically," says Maurice J. Dunne, chief engineer at Unimation. The changes largely result from efforts to add greater reliability and lower costs. Claiming more than 500 robots in the field since the first was delivered in 1962, Unimation, a Condec Corp. subsidiary, has more robots installed than any other company.

Echoing Dunne's estimate of the progress made in electronic hardware is Ralph J. Mosher, president of two-year-old Robotics Inc., an Elnora, N.Y., company formed to develop industrial robots. "Until now, the field has been held back by the complexity, high cost, and even unreliability of the position-feedback servos needed in programable robots," says Mosher. "But the upgrading that has occurred in electronic components has been tremendous." Mosher also cites such developments as plastic potentiometers for the feedback transducers, which have vastly improved linearity and life. And with integrated circuitry has come lower costs.

Changes come slowly

Although a new company like Robotics or USM Corp. can begin with the latest technology, the process of changing the electronic design, as for most industrial devices, has been slow. It was not until early this year that production Unimates were shifted from the discrete 18-volt resistor-transistor logic of the 1962 design to me-

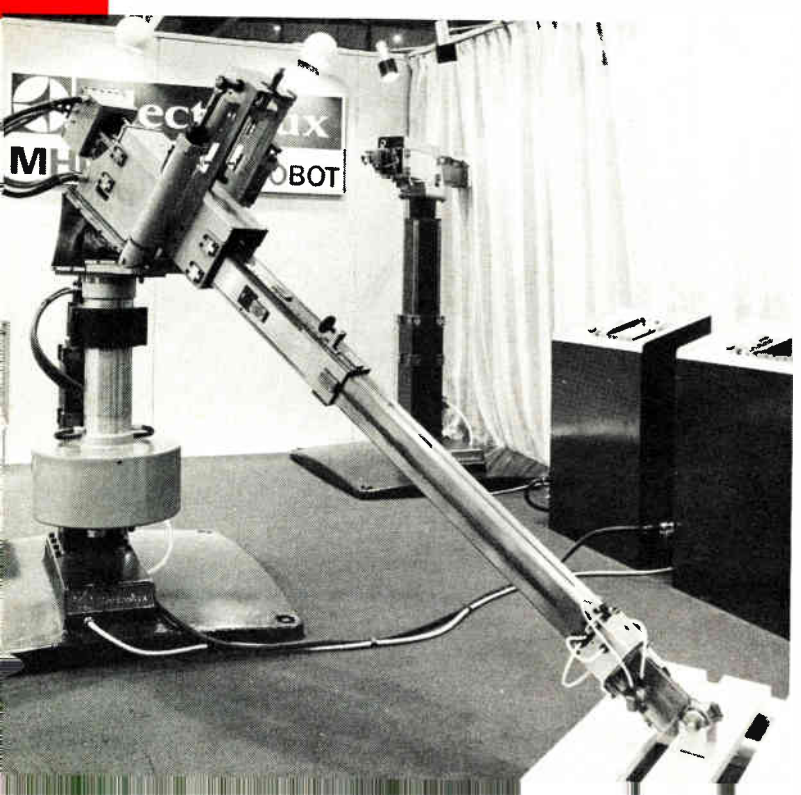
dium-scale integrated circuitry—5-volt 8000-series devices from Signetics Corp., Dunne says. With the number of circuit boards reduced, this substitution also meant a complete repackaging of the central processor unit.

In addition, Unimate substituted a plated-wire memory, offering modules of 128 program steps to a total of 1,024, [*Electronics*, Aug. 30, 1971, p. 25] for the less reliable stepped magnetic-drum memory of the company's own design. Although this design change was decided upon in 1971, the new memories did not begin to appear in production machines until late last year, following extensive field tests. Particularly important, of course, any new design must operate satisfactorily in the noisy electrical environment of the usual factory. The long lead time in making such changes is partly due, Dunne says, to the need for scheduling production runs well ahead of time. "Like a change in any model year, we had to finish out our already planned build," he explains. "The majority of our design effort goes into engineering the thing to exist as it is for a very long time. It's inevitable, for example, that we'll convert to large-scale integrated circuitry, but I couldn't predict when that would be."

The standard Unimates are five-axis machines. The smaller series 2000, for example, has an arm that extends out to almost 8 feet from its pivot point, which can position its payload repeatably to within 50 mils. Quite large, the hydromechanical package weighs 3,500 pounds, stands 4½ feet high, and measures more than 5 feet by 4 feet.

Thus, in addition to its high price, the Unimate may lose out because potential users don't have the space to devote to it. Accordingly, although Unimation for years has been the champion of flexible multipurpose robots, it has recently become the U.S. representative for the smaller, less flexible MHU robot from Sweden's Electrolux Co. And in addition, it is marketing the continuous-path robot designed strictly for paint-spraying applications, made by Trallfa, a Norwegian company.

Boarding-house reach. Materials Handling Unit (MHU) from Electrolux in Sweden, marketed in the U.S. by Unimation Inc., is a less flexible but less expensive addition to the Unimate family.



Analog technology is common

Whereas the Unimates store programed positions and functions in digital form, most of the others rely on analog technology similar to the programable manipulator developed by AMF Versatran, considered the No. 2 robot manufacturer behind Unimation.

"The two companies complement each other rather than compete directly," says Versatran's Van Horne. "The Versatran is physically smaller than the Unimate, and it has a shorter reach. It's also more modular, with its electronic control and hydraulic modules capable of being mounted remotely from the manipulator itself." This enables the Versatran to fit into cramped places where the Unimates can't, as well as enabling them to be suspended upside down or positioned sideways from a wall, he notes.

Van Horne points out that the maximum weight a manipulator is specified to handle may also include the tooling needed to grasp the part. He cites one case in the automotive industry in which a 43-pound cast-iron intake manifold for a Cadillac engine had to be manipulated with tooling weighing 60 pounds.

Versatran manipulators are designed for either point-to-point or continuous-path control. Positions to which the manipulator moves are stored in analog fashion in wire-wound potentiometers. The hand and arm then move until feedback potentiometers in servo loops on each axis of motion balance the storage pots. Zero-output conditions shut off the hydraulic control valves, and the arm stops.

The sequence in which the manipulator moves to the points, and the functions—such as CLOSE HAND or WAIT FOR AN EXTERNAL SIGNAL—are set up by connecting points in a modular program panel. A solid-state ring counter activates each 10-step module. Interlocks are also established with external sensors and equipment. Such interlocks could, for example, allow the hand to close only when a signal is received that a part is in place. Or the interlock could signal an external conveyor to move, once a part has been loaded. With such interlocks, the Versatran serves not only as a manipulator but as a controller for the machines around it, points out Van Horne.

Pots are now modular

When first introduced almost a decade ago, the Versatran was supplied with a bank of 36 potentiometers for the three basic movement axes. But about four years ago, the machine was redesigned to accept plug-in modules of six or 12 potentiometers each. (At the same time, the weight-lifting ability was raised to 150 pounds from 25 pounds.)

With its plug-in modules and the ability to share potentiometers through the patch-board control, Versatran's standard series 302 point-to-point control has a capacity of 4,000 sequence points, with a capability for subroutining of task sequences such as those needed, for example, in palletizing operations. Some point-to-point units in the field can, through back-panel wiring connections, even handle as many as 14,000 points.

Another version of the Versatran provides for continuous control of the path of the manipulator arm. The same mechanical and feedback elements of the point-to-point machine are used here, but the analog dc signal levels at the feedback pots are converted to digital signals and stored on five- or seven-channel ¾-inch magnetic tape. A channel is used for each of up to five servo-controlled axes, another channel for the system clock, and another is the command channel to control auxiliary functions by signalling relay closures.

The digital path coordinates are continuously recorded on two 12-minute magnetic-tape decks. Playback is at the rate of 60 pulses or points per second. It's also possible to use still larger tape decks, and in the future, the unit may be controlled by a central computer.

The continuous-path machine is programed by plugging a "steering" module into the end of the arm and having an operator steer the arm through the motions of the task. At the same time, he electrically cues in auxiliary function signals as the entire program is recorded on the tape.

Price of the point-to-point Versatran starts at about $14,000 for a two-axis mechanical unit and its associated controls, says Van Horne. A hydraulic power source and end-of-the arm tooling are extra. A three-axis machine starts at less than $18,000. The usual installation, with anywhere from $2,000 to $5,000 for tooling and application engineering, probably amounts to slightly more than $20,000.

Sophistication—under test

One of the most sophisticated machines is a minicomputer-controlled manipulator from Sundstrand Corp. Still in the test market phase—no devices have been sold—it has been used by Dow Chemical Co. to handle radioactive materials at its Golden, Colo., facility.

The mechanical assembly is a five-axis manipulator, basically a rotating column equipped with a two-part arm ending in a wrist unit that is free to move in two planes. Driven by electric motors, the Sundstrand robot occupies 16 × 16 inches of floor space, slightly less than a Versatran, has a lifting capacity of 25 pounds, and features a programable accuracy to within 12 mils and a repeatability to within 2 mils of any programed point.

"Our original conception was a hydraulic robot, but we went to an all-electric system to get accuracy," says Carl Pearce, project engineer for the robot at the Machine Tool division, Belvidere, Ill. "The big advantage is considerably fewer maintenance problems. That, of course, parallels the experience on numerical-control machines—now almost totally electric."

Sundstrand is using a Data General Nova 1200 with a basic 4,096-word memory. The main reason for going to computer control was the ease it affords for controlling multirobot installations and particularly for changing programs, says Pearce. Programing is accomplished on a point-to-point basis with a detachable control. "Basically, we move it around with a joystick," points out marketing manager Fred Ditto. The technique is similar to the way the Versatran is programed. "This drives pulse motors, and pulse counts are collected in a buffer. To record points, the operator hits a 'store' button and the information's sent to the computer."

Although the investment for the first robot may be high—more than $30,000, including minicomputer and teletypewriter—Pearce says the cost will be justified as additional robots, at $20,000 each, are added to the system. "The Nova 1200 will address up to 32k of memory, and there's nothing to keep you from tying millions of bits of disk to this," Pearce says.

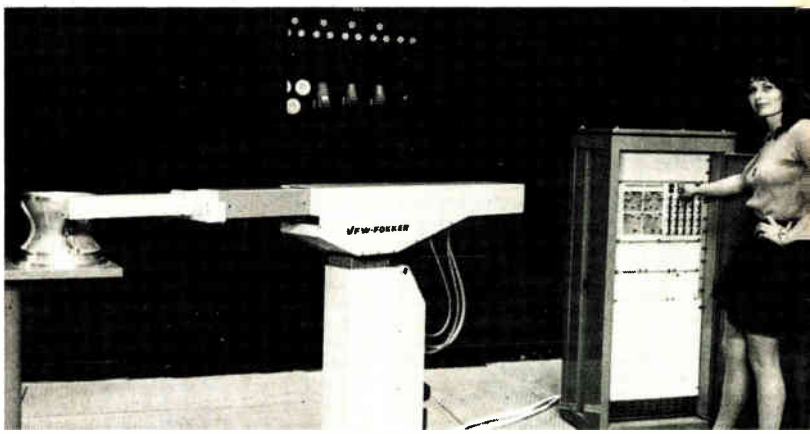
"The executive program occupies in the neighborhood of 2k, and an application such as machine loading and unloading, takes 400 words of memory storage," he explains. "That's enough for five robots, without the addition of core." It's possible to teach one robot and use the data for all of them, Pearce continues, or each robot can be taught completely different tasks.

As far as moving into the industrial marketplace, the Sundstrand machine will have to be faster, admits Ditto. "We know what we have to do—add bigger and faster drives. But the state of the robot market makes us move cautiously."

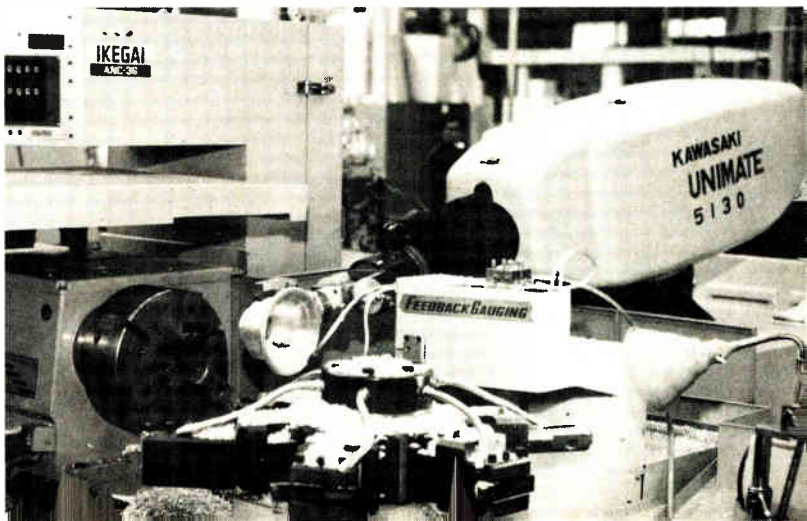
Minicomputer controls bow

Others have also been working with minicomputer-controlled robots, including Kawasaki in Japan and Hawker-Siddeley in England. The USM robot also benefits from a new technological twist. Starting fresh, the company decided to control its robot with a PDP-16 programable controller, the solid-state Digital Equip-

Attention. West Germany's VFW-Fokker Transferautomat E is actuated by printed-circuit-board motors and programed at a patch board with positions stored in potentiometers. Capacity is 66 lb.



Oriental touch. Kawasaki Heavy Industries, licensee of Unimation Inc., has sold more than 100 of the machines in Japan. And it is developing its own continuous-path and minicomputer-controlled units.



ment Corp. device that's been replacing electromechanical relay banks on assembly-line tools performing repetitive tasks.

As many as 50 program points, as well as auxiliary functions, can be set into the PDP-16 read/write memory. Two of the machine's five-plus axes are controlled pneumatically and the others by stepping motors. A prototype of the robot is being used at one of the USM plants to serve three punch presses. Eventually, the company hopes to sell it for less than $20,000, although Manning, the marketing director, has no definite date for its introduction.

Typical of the companies getting into the market for manipulators, virtually mandated by toughened state and OSHA regulations, are companies like the Syncro-Trans Corp. subsidiary of Davis Tool and Engineering Corp., Detroit, Robotics, the Prab Engineering Corp. subsidiary of Prab Conveyors Inc., Kalamazoo, Mich., and Wickes Machine Tool division of the Wickes Corp., Saginaw, Mich. In general, their machines are more limited in the number of individual operations they can be set to perform, and they cost less than the more flexible and more powerful machines pioneered by Unimation and Versatran. Most are designed for handling lighter-weight parts.

Whereas Unimate and Versatran units can lift up to 150 or 300 pounds, the maximum weight handled by these other machines is usually much less—in the range of 5 to 50 pounds. However, the Wickes Grabber is rated at a maximum of 100 pounds.

One of the most successful of the smaller manipulators, with more than 300 claimed to be in the field, has little need of electronics. This is the Auto-Place robot from the Auto-Place division, Erie Engineering Corp., Troy, Mich. It is a pneumatically actuated manipulator programed from a pneumatic logic module.

In addition, it is relatively low priced, selling for as little as $1,600, plus about $1,600 more for a pneumatic logic unit. One model lifts only a maximum of 10 pounds, another as much as 30.

Pneumatically controlled manipulators, however, aren't limited to handling small parts. The hydraulically actuated Brute manipulator made by Burch Controls Inc., Kalamazoo, Mich., for example, has models that can lift from 500 to a few thousand pounds.

The Auto-Place, like several other robots, was first designed for its parent company's own use. Erie Engineering is a designer of dies for the automotive industry. The company wanted the robot to replace a human operator in the dangerous job of placing and removing parts from its machinery.

Similar events occurred at Davis Tool and Engineering Co., Detroit, which is involved with stamping out metal parts for the automotive industry. Davis specified the manipulator and went to a Japanese firm, Keiaisha Manufacturing Co., to work out the detailed design and fabrication. In November 1971, Syncro-Trans Corp. was formed to market the robot.

The company has a pair of two-axis, pneumatically actuated units that can handle up to 20 pounds to an accuracy of a little more than 30 mils. As many as 24 separate steps can be programed through a diode matrix pin-board panel. Relay logic converts the programed information into signals for driving the valves on the pneumatic actuating system. Mechanical stops limit the arm movements. The robot is priced, with control panel, at under $11,000. The company also has a unit with IC logic selling for about $12,500 and a bigger and heavier machine on the drawing boards.

"We're aiming at the low-cost end of the market, generally at the less sophisticated shop," says marketing manager Robert W. Reinhardt. The Syncro-Trans robots, he continues, are difficult to reprogram, compared with Versatran and Unimate machines, because they rely on moving diode pins in a matrix panel and changing the mechanical stops.

One robot has even been developed for a manufacturing process that's yet to be accepted. This the ShapeMaker machine from Robotics. It's designed to trace a continuous path while applying liquids or pastes to form gaskets for automobiles, replacing the separate gaskets now being used.

In the ShapeMaker, Robotics applies the same mechanical and servo elements it uses in its Liberator robots—a line of point-to-point robots that can lift up to 70 pounds. However, the ShapeMaker relies on a proprietary analog memory to produce continuous analog signals for two-dimensional control, says general manager Donald L. Shell. The unit, which lists for under $25,000, is programable, but a new generator memory must be made for each shape. A unit capable of three-dimensional operation is also being developed.

Europe also makes robots

In Europe, Scandinavia leads in robot manufacture and application. Elsewhere in Europe, the University of Nottingham in England is working on advanced robot designs that employ visual and tactile sensors, and Hawker-Siddeley, a licensee of AMF Versatran, installed its first minicomputer-controlled robot as early as two years ago.

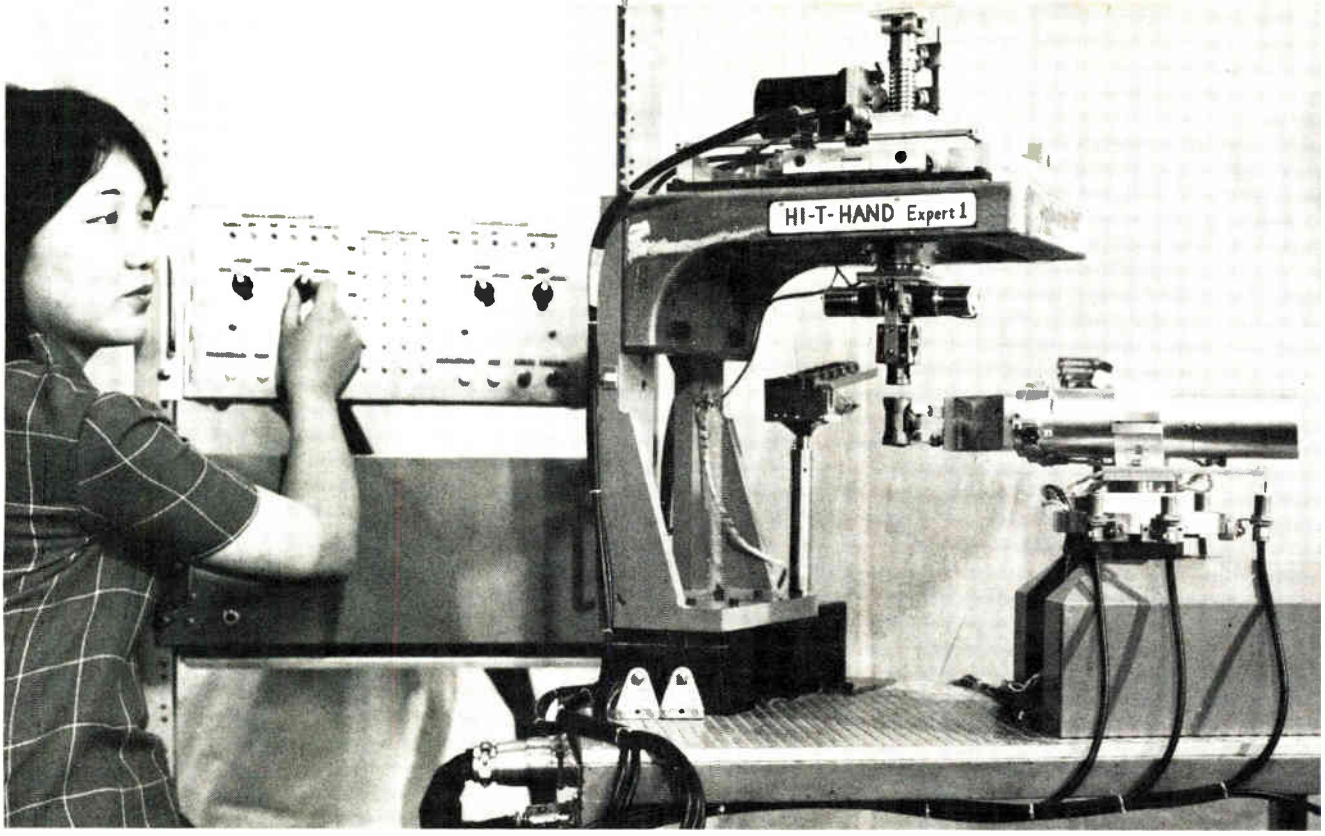
Other countries have developed their own robots too. West Germany, for example, has VFW-Fokker's Transferautomat E, a $23,000, three-axis, electrically actuated machine that can handle more than 65 pounds. And in France, Koenig Automation S.A., Rixheim, has developed its Roboka-series machines for parts weighing from about 10 and 65 pounds.

With 200 robots in operation, Sweden's R. Kaufeldt AB of Huddinge (outside Stockholm) is one of the world's top three robot manufacturers. Another Swedish company, the giant conglomerate Electrolux, says its West German agent, Robert Bosch, has agreed to sell 150 robots within the next two years.

Moreover, the Norwegian company, Trallfa, has successfully developed a specialized robot for paint-spraying applications. In only a couple of years, it has put 110 in operation and has 50 more on order, despite the fact that the unit is relatively sophisticated and priced at upwards of $25,000.

Starting at $6,000, the Kaufeldt robot is a small, relatively inexpensive machine finding wide use in the plastics industry, primarily in Sweden.

Top weight lifting capability of the pneumatically powered Kaufeldt is 145 pounds, though it weighs only 350 pounds itself, and even in its lowest-priced form, it



Pretty smart. Experimental tactile robot from Japan's Hitachi Ltd. consists of a main hand and an auxiliary hand that can insert a piston into a cylinder with extremely tight tolerance. Hitachi is a leader in developing robots with both visual and tactile senses.

has five axes of motion. Usually, it is applied to handle workpieces of less than 30 pounds. Position accuracy can be held to variations of less than 2 mils.

Programing is simple

Both the Kaufeldt and Electrolux robots use relatively simple programing and control systems made by Sweden's telecommunications firm L M Ericsson. These systems, similar to those on telephone exchanges, incorporate electromechanical relays; programing requires adjusting their hardwired connections. This slight programing difficulty can be an advantage. "Our customers in Italy like this feature," says Lars-Eric Qvist, Kaufeldt's managing director. "They say their workers like to play with buttons and switches, and they can easily foul up programs if these are easily accessible."

The basic control unit offers 58 movements, with a horizontal reach of almost 50 inches, but it is modular, and $60 buys an add-on control unit with 30 more movements. Robots with capacities of 240 movements have been supplied by the company. On two Kaufeldt robots recently introduced, new control systems have replaced the Ericsson board. One has an plug-board made by the Swiss electrical firm of Brown-Boveri and Co. and marketed under the trade name "Sigmatronic." The other robot is controlled by a fluidic system made by Knorr Fluidics of Munich. The robot was designed to meet explosion-proof requirements for an installation at the Nobel explosives plant in West Germany.

Electrolux's MHU (for materials handling unit) resembles the standard Kaufeldt robot. It also uses pneumatic power and the standard Ericsson control board. Its configurations can be varied—a simple arm-and-hand setup suffices for horizontal or vertical movements, or a tilt unit allows the arm to reach down at a 45° angle so that it can pick objects from pallets. Price ranges from about $9,000 to $17,000, depending on configuration. Electrolux has also come out with a smaller model, known as MHU Junior. With one or two arms, it is priced at between $7,500 and $10,000.

Control is magnetic tape

The Trallfa robot, made by the Trallfa Co. in the small town of Bryne outside Stavanger in Norway, features movement controlled over a continuous path by magnetic tape in a fashion similar to the American-built Versatran. One of the first production models was put into operation in 1969 to enamel bathtubs at the Gustavsberg enamelware plant outside of Stockholm. Of the 110 units in operation, at least 10 are in the U.S., and the rest are in Europe, Japan, and East Germany.

To program the unit, the operator moves the spray head around the object to be painted, duplicating the job as he would do it manually. The unit has five different servo systems to duplicate the movements of a hand and arm. Analog signals from the position servos in each axis are converted to digital signals and recorded on eight-track tape. The memory system, in playback, compares the position of the resolvers and potentiometers and thus knows the spray-head position and the next move. The servo system is pulsed 80 times per second.

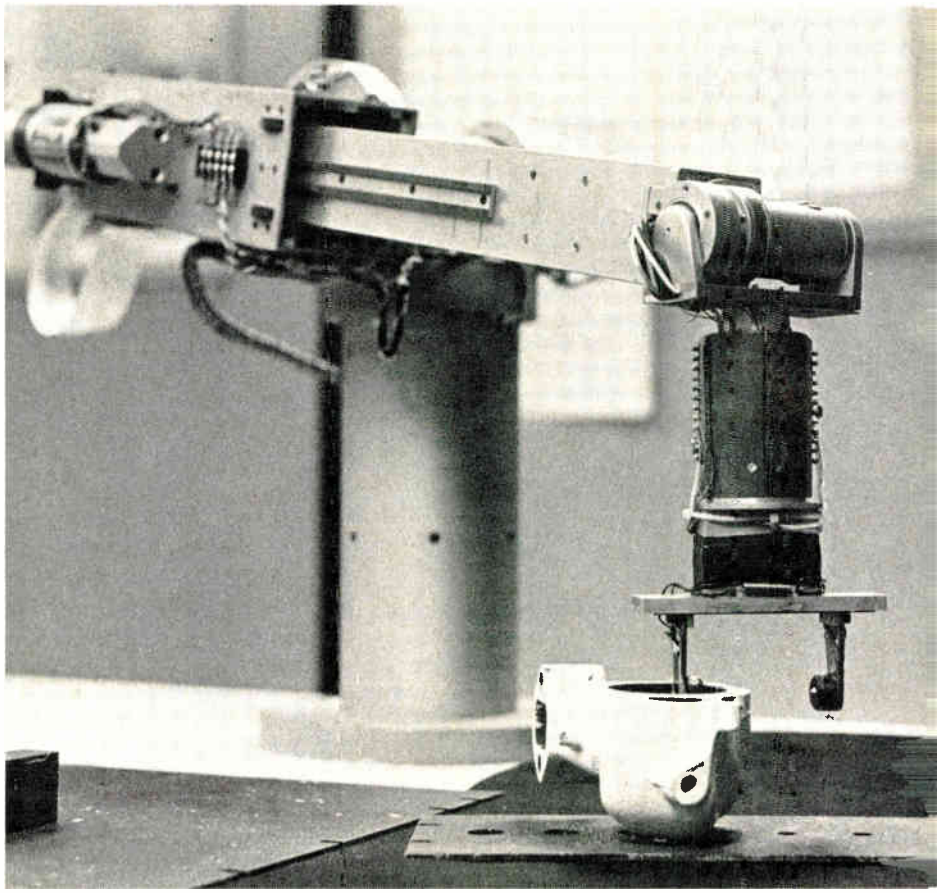
Accuracy of the Trallfa is roughly to within ±80 mils—not good enough for a lot of pick-and-place jobs, but good enough for spray painting. The robot is activated on the line by photocells or proximity switches.

Retab is sophisticated

On the control side, a Stockholm company, Retab, has produced one of the most advanced electronic robot

Inventor. Victor Scheinman adjusts the Stanford University robot arm.

Duo. Richard Paul, typing, and Robert Bollis program the Stanford arm.



Gently. Hand at end of four-foot-long arm of Stanford University robot delicately sets down housing of small pump it has been programed to assemble.

control systems available— one that even affords the possibility of tying in remote sensing devices so the robot can locate objects whose position and orientation need not be firmly fixed.

Retab, which stands for Rationella Elektronik Tillaempningar AB, hopes to sell its control as a general-purpose system for servo-controlled, hydraulically actuated robots. Founded in 1964, the company builds numerical-control systems for drilling printed-circuit boards. Its new control unit operates from a cassette tape or a solid-state memory, consisting of a dynamic MOS shift register made of 20 2,048-bit chips.

The control is programed by the teach-in method. The Retab is put through its paces manually while the positions and functions to be performed are stored in its MOS memory. The memory can store 250 points in a six-axis system, or 500 points in a three-axis system. A completed program can be shifted to tape for a permanent store.

The unit offers up to three memories in any combination of tape and solid state. Thus, using two tape memories, each with a capacity of 5,000 points, total memory capacity of 10,500 points can be obtained.

Unusual is a search mode, which helps the robot locate objects. Instead of a sophisticated TV or tactile sensing system, the Retab controller reacts to signals from photocells or other sensors. Thus, a series of light beams may be placed across a table so that an object on the table breaks the path between the light source and photocell. The robot arm is then automatically controlled to move to the object. Retab officials say that such an operation can be accomplished at the robot's full speed.

Retab's controller has been operated with a Japanese robot, made by Tokyo Keiki Co., but no sales have been announced yet. A basic unit costs about $10,000 with one memory module of 250 positions. Additional MOS-memory modules cost about $500 each, while the tape recorder costs about $1,100.

Japanese industry

Some of the largest companies in Japan are building robots. Thus, companies making fairly sophisticated robots include Tokyo Shibaura Electric Co. (Toshiba), Hitachi Ltd., Daido Steel Ltd., Kawasaki Heavy Industries Ltd., Mitsubishi Heavy Industries Ltd., Ishikawajima-Harima Heavy Industries Ltd., Fujikoshi Ltd., Nagoya Kiko Ltd. and Tokyo Keiki Ltd.

The most successful manufacturer of sophisticated programable robots is Kawasaki, which makes Unimate machines under license, as well as developing its own versions. These latter robots include a continuous-path machine, and at least two that operate under minicomputer control. Kawasaki officials claim that commercial customers have ordered two systems with minicomputer controls. Altogether, Kawasaki has sold more than 100 of its Unimates and claims perhaps 10% of the market.

Just behind Kawasaki is Daido Steel, which is the Japanese licensee of the AMF Versatran. Daido's robots

include various models of the Versatran, the Minitran robot licensed by Hawker-Siddeley, the British AMF Versatran licensee, and more specialized robots used in metals casting and as overhead loaders for presses. Prices of the Kawasaki and Daido Steel installations range from $19,000 to $50,000. Except for the Minitran, the Daido and Kawasaki robots are in the heavy-weight-lifting class. Other companies in that same class include Yaskawa Electric Ltd., and Fuji Electric Ltd., with a 400-pound-plus machine.

Simple manipulators do well

However, these companies are not typical suppliers because the bulk of the market is served by a large number of relatively simple and inexpensive robots. And even where the larger units are applied, no single production line has as heavy concentration of robots as, for example, General Motors' Vega line in the U.S.

Among the top manufacturers in Japan is Ichikoh Industries Ltd., which specializes in a simple robot for loading and unloading thermoplastic injection-molding machines. These robots, pneumatically actuated and relying on switches for positioning, may merely deliver a completed part as heavy as 21 pounds onto a conveyor. An Ichikoh spokesman sees an attractive market for the robots—about 800 of the molding machines are made each month, he says.

Another specialized manufacturer is Aida Engineering Ltd., which says that 90% of its robots are used for loading and unloading presses. Not so coincidentally, perhaps, Aida also manufacturers presses. However its robots are used on other presses as well.

Aida exports its robots to the United States, and so does Sanyo Machine Works Ltd. Sanyo makes a low-priced, light-weight robot that features mechanical-cam programing and diode-matrix pin boards. Prices of the Sanyo units range from $3,800 to $7,600.

Several Japanese companies are also developing minicomputer-based controls for their robots, as well as controls to direct groups of robots from central computers. Included are Kawasaki, Mitsubushi, Toshiba, and Tokyo Keiki. Kawasaki, for example, working with a subsidy of about $319,000 per year from the Ministry of International Trade and Industry, is developing under a three-year program a pilot plant that uses eight-axis robots for the automatic assembly of automobile engines. The installation has been operating experimentally since last year.

One trend noted by a Kawasaki spokesman is that its large Unimate-type robots are going into assembly lines designed especially for the robots. One such line in the auto industry, for example, has eight robots doing spot-welding. And in about a year, a similar line under minicomputer control will go into operation.

In developing industrial robots with advanced sensors, Hitachi's Central Research Laboratory is an industry leader. Its latest development is a two-handed, tactile-sensing device, the Hi-T Hand Expert 1, that can insert a piston in a cylinder having a clearance of only 20 micrometers. This clearance is so small the parts seem to freeze together unless the insertion, made with the help of tactile sensors in the hands, is precisely on target. Other Hitachi robots have been fitted with TV cameras and pattern-recognition schemes to find and grasp objects, and to develop hand-eye coordination.

Although robots with tactile and visual sensors have been called the next step in technology for years, none of the robots now operating in factory environments are so equipped. But work on the new sensors goes on nevertheless, at such institutions as Stanford, Stanford Research Institute, and MIT in the U.S., Nottingham in England, and Hitachi Ltd. in Japan.

Typical of the advanced industrial robot development is the work going on in California at SRI and Stanford. Under a National Science Foundation grant, SRI is developing a computer-controlled assembly machine with tactile and visual sensors. Work under the grant started April 1, and funding has been received for a year. If progress is satisfactory, NSF is to provide some $550,000 over a two-year period. The test bed is a Unimate robot equipped with a hand carrying tactile sensors and with a television camera for visual sensing. A second smaller arm will be installed, as well, for two-handed assembly work.

Prime goals of the SRI program are to develop programing techniques suitable for general-purpose industrial robots and to resolve questions about what kinds of sensors, hands, and other components are required for practical industrial work.

Highest priority for the robots goes to carrying out assembly operations, followed by inspection of parts and checking for such things as misorientation of a component, a hole not drilled, or threads that have been stripped, and, finally materials handling.

The NSF grant specifies that SRI be guided by actual industry needs so that any technology that's developed will stand a good chance of being used. To achieve this objective, the project director, Charles A. Rosen of SRI's Artificial Intelligence Center, is enlisting companies from as many as 10 different industries as fee-paying affiliates. AMP Inc., the Harrisburg, Pa., manufacturer of electrical connectors was the first to sign up.

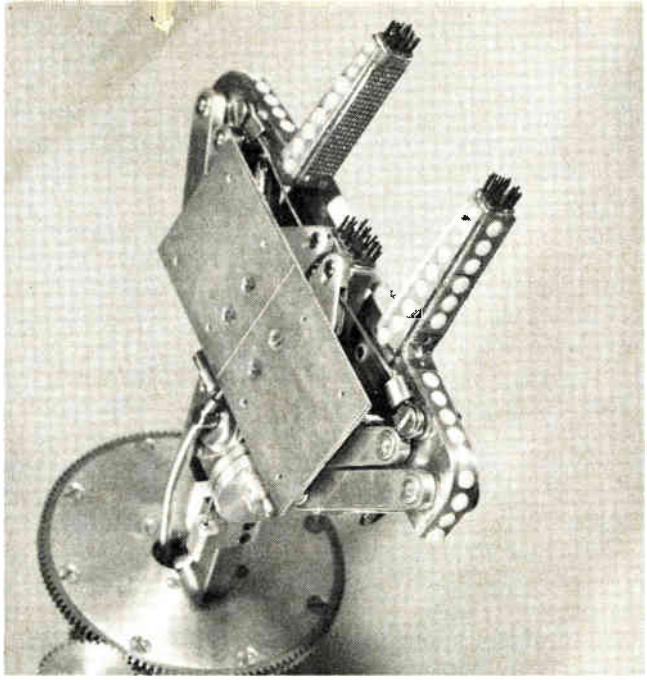
Minicomputer control planned

Rosen hopes the project will lead to development of dexterous, general-purpose machines costing around $50,000 with minicomputer controls. The minicomputers may be built-in or several machines in a line may be controlled by a larger computer. He expects such machines might have a capital cost write-off life comparable to numerically controlled machine tools—perhaps 10 years—making them economical for many industrial applications.

The sensors will be versions of ones that SRI has been developing under other programs. One will be a hand with flexible fingers and analog touch sensors. These sensors will be interrogated by the computer through a multiplexer.

For instance, if a part is being pushed, a row of sensors along the outer edge of the finger doing the pushing will allow the computer to "feel"—by referring to stored patterns—when the part comes in contact with another part. Rosen is considering adding torque sensors. He notes that MIT has developed an excellent torque-sensing system.

A TV camera will be the basic visual sensor, possibly



Sensitive. Early model of SRI hand had touch sensors added to detect force it exerted on an object.

to be replaced in the future by solid-state scanning arrays. These scanners will probably be combined with laser scanners to provide depth information. Rosen believes that laser scanning is a more economical and accurate way of obtaining depth information than stereoscopic processing.

The visual ability will be used for such things as checking parts orientation and parts integrity—that is, such things as determining if a punched part has the right number of holes—and guidance as to where to grasp parts. And "templates" in the computer software would compare scenes viewed with scenes stored in memory. From these comparisons, the computer can determine how to direct the robot mechanisms.

With the smaller second arm added, the larger arm could, for example, serve as a programable holding jig for a large part, while the small arm inserts smaller parts and handling tools. Rosen also hopes to develop methods for coordinating two-handed operation.

Sensors may upgrade robots

He notes that robots available today—such as Unimate—could be upgraded by sensors, but that manufacturers have been fearful that the machines would be too costly for the market. Plans are to run the machine at least initially with a Nova minicomputer, and to develop software that will allow jobs to be programed interactively by people who are not skilled programers. For instance, to define a part the programer might call out a basic shape on a display screen. The shape would be uniquely defined by its center of gravity and a measure such as the ratio of two radii.

Then, the display operator could indicate with a light pen the points at which the part should be grasped by the robot. Then, by various "natural" programing methods, the manipulative sequence would be assembled to complete the setup program. While the programing itself might require a large computer, the program could be run on a mini.

Stanford University's Artificial Intelligence Laboratory (SAIL) has been researching hand-eye automation techniques for about 10 years under some $4 million in contracts with the Advanced Research Projects Agency. Some of the early work concerned space robots, but much of the later work has been on industrial robots. Current funding is about $350,000 a year.

The present test bed for industrial robots is a servo-driven, four-foot-long computer-controlled arm with six degrees of freedom. It has been used to assemble small pumps and will soon be programed to assemble a small motor, says Lester Earnest, SAIL's associate director. The robot could be scaled down to assemble smaller parts—conceivably, IC packages—or scaled up to assemble other modular building blocks.

This year, an extra hand will be installed so that the machine can do two-handed work. Most of the research effort now is concerned with vision programing and development of a high-level programing language. The servo programing is highly advanced so that the machine, much like a blind person, can assemble parts by groping and feeling for them. However, the vision software is only developed to the point where alignment targets, plane shapes, and the like can be sensed through a TV camera. Under development are programs that allow the machine to recognize curved shapes and use the shape data to control operations.

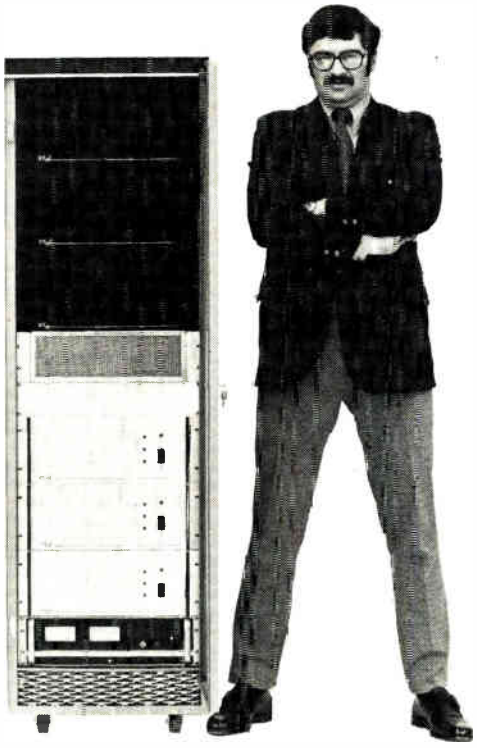
The robot's ability to "feel" makes it unnecessary for parts to have tight tolerances or be precisely aligned. For example, if a bolt must be screwed into a threaded hole, the hand picks up the bolt and moves it to the approximate hole position. Then the hand probes until the bolt slides into the hole, and it turns the bolt until it senses that the threads mate. If the bolt meets resistance, the hand backs off and tries again. A conventional manipulator or a numerically controlled machine tool would merely keep turning and could strip the threads.

The machine can be taught assembly steps directly. First, the hand is moved to the desired positions, and their coordinates are entered. Force and other data are entered at the computer terminal. From such inputs, the computer program—on a Digital Equipment Corp. PDP-10—plans arm motions, called trajectories. As the arm moves, forces impeding motion are sensed by monitoring the electrical currents driving the servos. The computer program then adjusts the servo-drive pulses to compensate for these forces.

In the works are plans to modify the program so that a laser beam could be focused across the part and be reflected into a TV camera. Each object will be considered as a combination of primitive shapes that reflect the beam in unique ways. Thus, a file of primitive images could be stored and used to recognize and analyze complex shapes and their orientations. Plane shapes, cubes, and the like can already be recognized.

Earnest says that about a dozen other laboratories have requested copies of the arm and its controls. He adds that a small company will probably be spun off from the lab to manufacture the device, which will probably be priced at about $5,000. □

Material for this report came from *Electronics* staffers Charles L. Cohen, Tokyo; Michael Payne, London; John Gosch, Frankfurt; George Sideris, San Francisco, and Larry Armstrong, Chicago, and from McGraw-Hill World News Correspondents Robert Skole, Stockholm; Laura Pilarski, Zurich, and Beth Macleod, Paris.



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C-MOS may help majority logic win designers' vote

Majority logic, in which output depends on the state of a majority of inputs, has just been introduced on an economical IC; it can markedly reduce the number of gates needed to implement a function

by Lane Garrett, *Motorola Semiconductor Products Division, Phoenix, Ariz.*

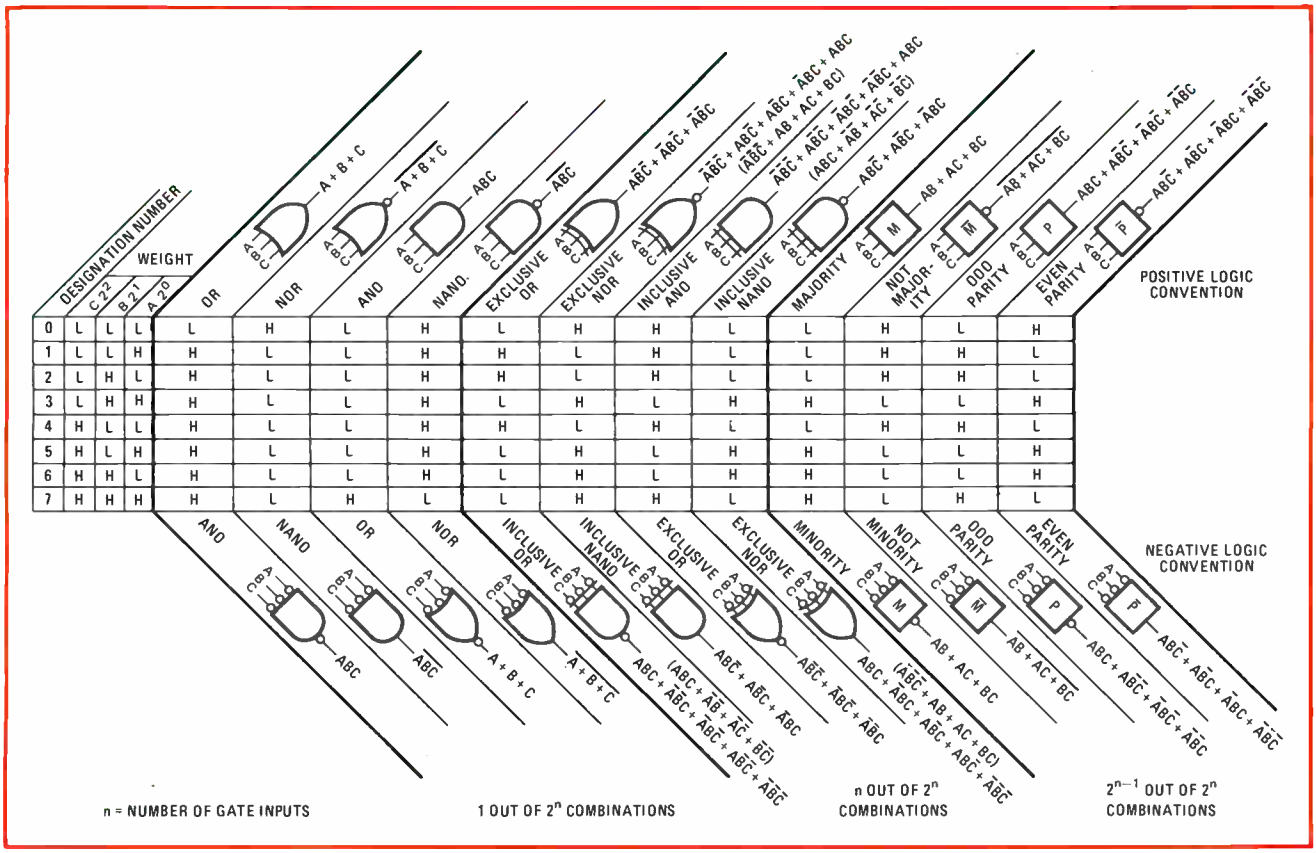
☐ The class of logic functions called "majority logic," which has long been dormant, is now being used as basic logic building blocks alongside conventional AND, NAND, OR, and NOR functions. Broadening the logic and system designer's list of useful tools, majority logic is defined simply as a function whose output depends on the state of the majority of its inputs. Devices having this capability often significantly reduce the total number of logic gates required to implement a function.

Already a new majority-logic chip built with complementary-MOS technology is available for functions that are otherwise difficult to realize—for example, in correlation techniques dealing with weighted variable values and in communications systems where information must be retrieved from noisy backgrounds.

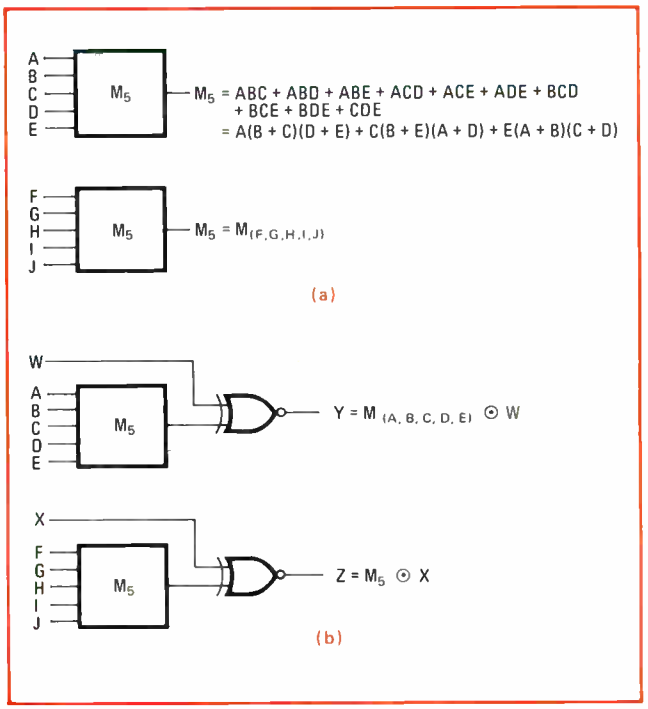
For many years, the generic class of threshold logic, of which majority logic is a member, has been known to logic designers, but its use has been confined to special or custom applications because no method existed to turn these designs into economical standard products. A threshold-logic function is defined as a decision block in which the output is true if the arithmetical sum of the inputs (each of which may have its own numerical weight) is greater than a predetermined number. Major-

Closing the loop

Readers who wish to discuss majority logic with the author may call Lane Garrett during business hours during the week of July 23 at (602) 244-3681.



1. The family. In this chart relating majority logic to the other basic gating functions, the left margin gives designation numbers and the eight possible high-low combinations of three input variables, while the logic symbols and Boolean expressions are given at the top and bottom.



2. Doubly flexible. The first majority-logic product, a dual five-input chip whose function is shown in (a), has good tradeoffs to get logic flexibility and low production costs. Moreover, adding an exclusive-NOR gate to each M_5 gate (b) enables the output to be logically inverted by applying a logic 0 to the W input. W may also be used as a variable to compare to the majority of the other inputs.

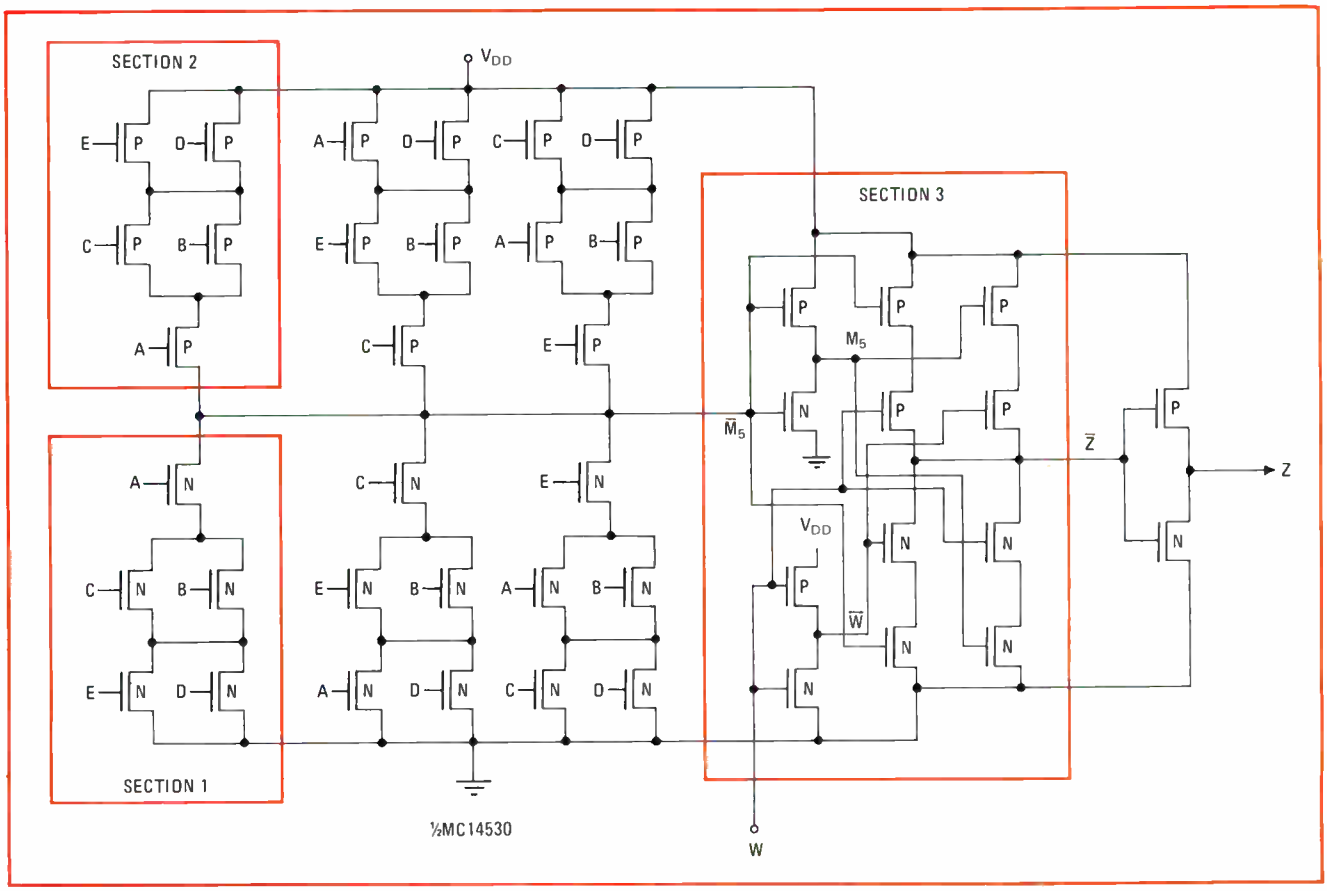
ity logic, which is most easily built in IC form, has, in every case, an odd number of inputs, each with a numerical weight of 1; thus, when more than half the inputs are true, the output is true.

Figure 1 relates majority logic to other basic gating functions. The left margin of the chart gives designation numbers and the eight possible high-low combinations of three input variables, A, B, and C. The logic symbols and Boolean expressions at the top of the chart are for the positive logic convention, while those at the bottom are for negative logic.

The majority-logic function

The four most common gating functions are shown in the left third of the chart: OR, NOR, AND, and NAND. It should be noted that, unlike majority logic, each of these gates detects one unique input combination out of all possible combinations. For example, the NOR detects the unique condition when all inputs are low and gives a high output. The next group of four gates makes up the exclusive and inclusive functions that have been defined for more than two inputs.

Taking n as the number of inputs to a gate, these functions sense n unique combinations out of 2^n total combinations. Out of a possible 2^n combinations, the last grouping of gates senses 2^{n-1} combinations, and these are the majority and parity functions. It should be noted that if all inputs are random in nature, the output of these functions can be expected to be true half of the time. The majority-logic function is most useful because



3. Operation. In half the logic chip shown here, each n-channel device of section 1 will be turned on when its gate goes high, while in section 2, conduction will occur when gate-input variables are low. Section 3 implements the exclusive-NOR function.

inputs may be used for both logic and control.

This new member of the C-MOS family is a dual five-input majority-logic gate (M_5). Because of the tradeoffs of production cost and logic flexibility, a five-input device was chosen, since five inputs are sufficient to demonstrate the flexibility of majority logic but are not too many to unduly complicate fabrication. Because present production costs of a 16-pin dual in-line package are almost the same as those for a 14-pin package, and the additional pins result in a significant increase in flexibility, the function shown in Fig. 2a was packaged in a 16-pin DIP instead of the conventional 14-pin DIP.

Inverting output

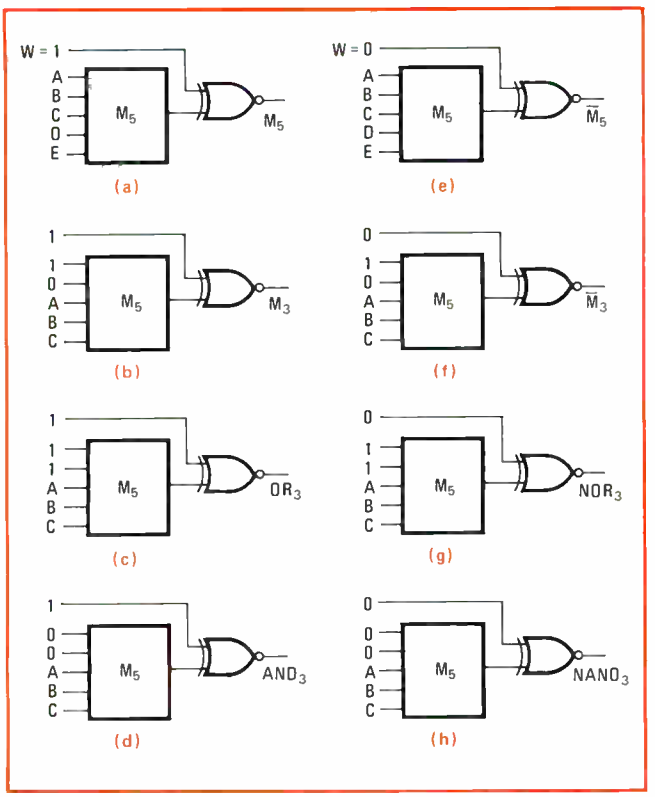
The two additional pins allow an exclusive-NOR gate to be added to each M_5 gate, providing two significant advantages as shown in Fig. 2b. The output may be logically inverted by applying a logic 0 to the W input. Also, the W input may be used as a variable that is logically compared to the majority of the other inputs, a function that cannot be easily implemented with conventional gates. The resulting logic component lends itself to numerous applications that were not heretofore economically practical.

C-MOS was chosen as the most effective technology for this function because it affords excellent packing density for complex functions otherwise uneconomical with such conventional bipolar technologies as transistor-transistor logic. And with C-MOS, speed is not significantly decreased with increasing complexity because devices can be built in tight arrays where chip delays are short. In addition, since the majority-logic function is symmetrical, it lends itself to easy implementation with standard C-MOS symmetry. On the other hand, the most economical bipolar technique for the implementation of complex majority logic is the summation of switched current sources—most effectively accomplished with emitter-coupled-logic design techniques that require more chip area and consume more power.

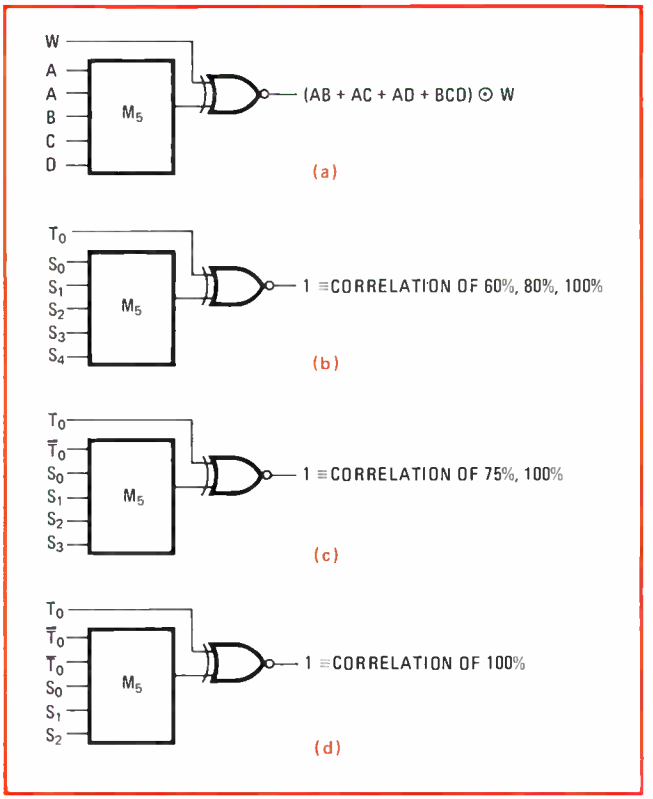
Majority-logic chip layout

The key to the design of economical, standard majority-logic C-MOS chips is the ability to make several on-chip devices do multiple functions so that complex majority-logic equations can be handled by fewer on-chip components. Consider the example $A(B+C)(D+E) + C(B+E)(A+D) + E(A+B)(C+D)$. Figure 3, which shows half of the M_5 layout, illustrates how the M_5 chip would implement this function. The n- and p-channel devices have been drawn with simplified symbols for the sake of clarity.

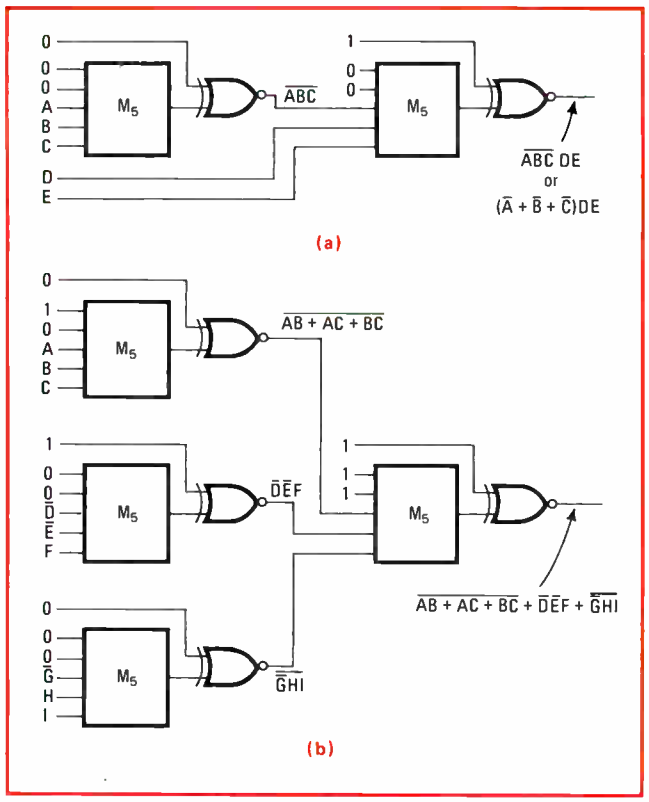
Each n-channel device shown in section 1 of Fig. 3 will be turned on if its gate goes high. Conduction can take place if A and (B or C) and (D or E) are true (high). Note that if conduction through the n-channel devices can take place, there is no corresponding conduction path possible through the upper p-channel devices. Conversely, section 2 will conduct if the input variables are low for the same expression, $A(B+C)(D+E)$. The next two series sections of Fig. 3



4. The M_5 chip's many combinational functions. Functions (a) through (d) represent the majority of five inputs and three inputs, the OR of three inputs, and the AND of three inputs. Functions (e) through (h) will give the complements of these expressions when the W input of the exclusive-NOR is changed from 1 to 0.



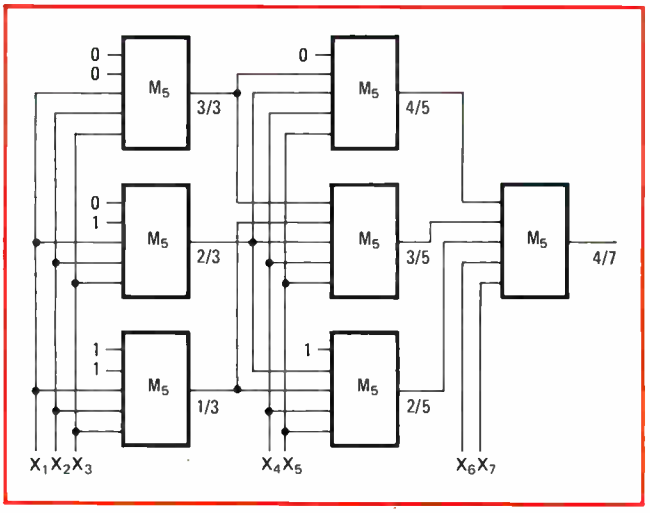
5. Weighing in. In correlation applications, special weight must often be given to a particular input. In (a), the input A is given a weight of two by repeating it once. Correlation of a test bit, T_o, with various input variables is also possible. The schematic in (b) illustrates correlation of 100% for a true or logic 1 output.



6. Levels of flexibility. The versatility of majority gates is increased by using two levels of the M_5 chip. In (a), the NAND of three variables is ANDed with two more variables. In (b), only two packages are required to get these complex combinational functions.

implement the last two major terms of the above expression.

The illustrated array implements the not-majority function, which is simply the complement of the majority function. Section 3 implements the exclusive-NOR logic function with only 12 MOS transistors. The last two transistors implement an inverter/buffer to drive off-the-chip capacitance. This last stage converts the logic expression into the exclusive-OR of not-M_5 and the W input, $(\overline{M_5} \oplus W)$ which is the logical equivalent of the original expression that was to have been implemented. Only 88 transistors are required to complete the entire function. This is less than half the number of devices required to build an equivalent TTL realization of the same function.



7. More than five. Majority gates with more than five inputs can be built from M_5 arrays. In this seven-input configuration the output 4/7 is true only when four or more inputs are true. The array can also be rearranged so that it will provide a 5/7 true output.

Fabrication of the chip in a small area is accomplished with a symmetrical layout. High-speed MOS devices are included to minimize gate-propagation-delay times and give good output-drive capability. At a nominal 10-V supply voltage, the over-all propagation delay varies between 100 and 200 nanoseconds with nominal load capacitance, depending upon the combination and number of inputs being switched.

As a standard product, the dual-majority-logic gate, (MC14530), is specified to operate over a supply range of 3 to 18 V with the same low quiescent power dissipation (typically 50 nW) common in standard logic families of C-MOS logic. For maximum compatibility, input and output characteristics are the same as other devices of the C-MOS family. Conversely, a TTL approach would yield a faster but more costly function that would dissipate significantly more power.

Applying the dual M_5 gate

The basic M_5 gate with exclusive-NOR is a powerful combinatorial logic function. In Fig. 4, which shows the basic M_5 configurations, the functions in Fig. 4a through 4d represent the majority of five inputs and three inputs, and the OR of three inputs, and the AND of three inputs, respectively. By changing the W input of the exclusive-NOR from a 1 to a 0, the complements of the previous four functions are obtained (functions 4e through 4h).

Figure 5a illustrates a method used for increasing the "weight" of a variable. Here the A input is given a weight of two by repeating it once, with the resultant Boolean output expression shown. The majority gate may also be used to indicate if the correlation between a test bit (T_0) and various input variables is greater than or equal to a predetermined value.

For example, Fig. 5b illustrates correlation greater than or equal to 60%, in Fig. 5c, it is 75%, and in Fig. 5d, correlation of 100% is required for a true or logical 1 output. By using arrays of these gates, it is possible to check the correlation factor between words stored in a memory and multiple samples of word data that have a large noise content. Thus, this correlation technique can be used for enhancing radar signatures and improving the performance of recognition equipment.

The versatility of majority logic can be appreciated from Fig. 6, which shows two combinational uses of M_5 gates. Figure 6a provides the NAND of three variables ANDed with two more variables, impossible with a single package in other logic families. By using only two packages in the configuration of Fig. 6b, many combinatorial functions of a large number of variables can be obtained with a significant savings in package count over other approaches. For the example shown, TTL requires twice as many packages.

The majority-logic gates may also be formed into arrays that are useful for detecting whether or not n bits out of m bits of a given word are true. This is useful in

conjunction with certain types of coding schemes involving a fixed number of 1s. Majority gates with more than five inputs can also be built with arrays, as illustrated in Fig. 7a. The general symbology n/m is used to illustrate that the majority gate is wired to detect whether n or more inputs are true out of a possible m input bits. For example, ⅔ states that the output is true if two or more of three inputs are true, i.e., M_3. The array in Fig. 7a is best understood by following through the array from left to right for the seven input bits, X_1 through X_7. It will be noted that the output 4/7 is true only when four or more inputs are true, i.e., M_7.

A general-purpose array is easily formed so that all possible cases of n/m can be detected. This is illustrated in Fig. 8a, where 15 M_5 gates (7½ packages) are required. If the exact number of true bits in the input word is required, the output of the array may be encoded into a 3-bit binary word through the use of a priority encoder (Fig. 8b). A priority encoder is an MSI function in which each input is assigned a fixed priority (0 through 7 in the example shown) and the output is the encoded binary equivalent of the highest-priority input that is true. This array is useful for checking the correctness of n/m codes and determining the number of bits in a word that correlates with a test word.

More correlation

Because of the ability to weight inputs in majority-logic sequencing, M_5 chips are ideal for applications where sensed data is to be compared to standards or various test words, and the degree of comparison or correlation is desired. Examples are in character-recognition equipment, speech recognition, radar-return analysis, recognition of various codes, and the recovery of information from noisy data samples.

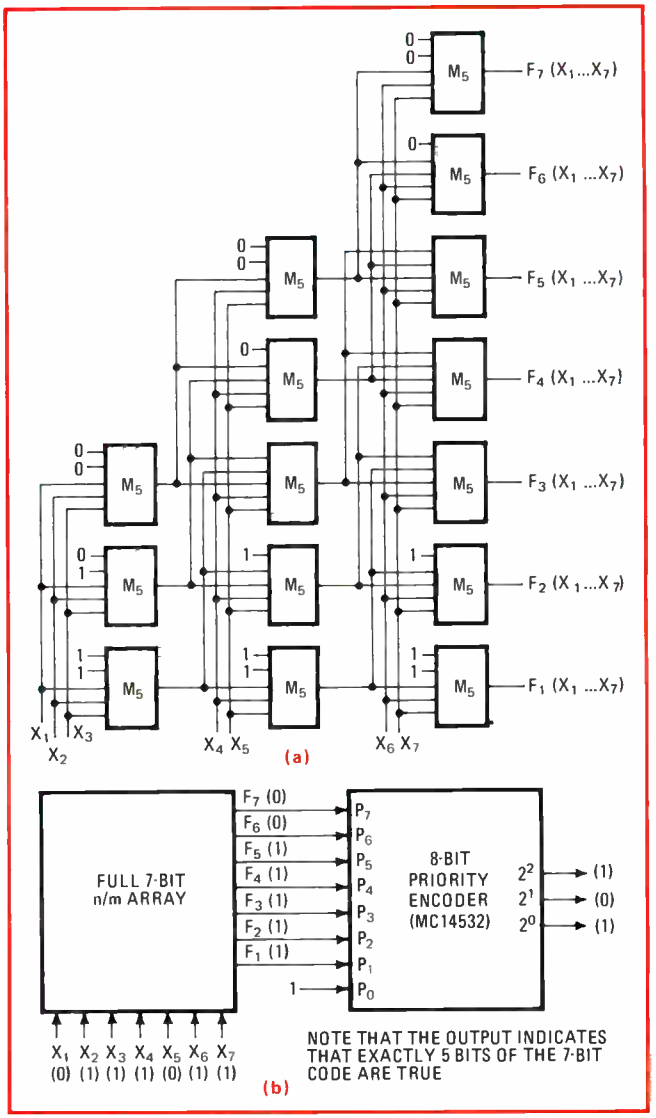
The array shown in Fig. 9, generic in nature, has been generalized for use in many correlation applications. Although this array may not be optimized for some applications, it presents a typical method of solution for many correlation problems.

In operation, the portion to the left of the figure consists of seven shift-register segments. Five flip-flops from each shift register are shown containing five time-sequential samples (S_1 through S_5) of one bit of a 7-bit data word.

The first seven M_5 gates vote on the five data-word samples. The majority of the five samples of each bit are then compared bit by bit with a test word (test bits 1 to 7). The result of each comparison is then available at the bit-correlation outputs.

Moreover, it is possible, by the method shown in Fig. 5, based upon the bit-correlation outputs, to deliberately feed back complements of the test bits to check for a higher correlation factor. These complements may be fed back in a serial manner and mixed with the data word in a predetermined manner.

The over-all correlation factor (on a word basis) is sensed by the 11 M_5 gates shown to the right. This configuration senses from 4 out of 7 up to 7 out of 7 bits in agreement with the test word. If none of the four outputs is true, the anticorrelation factor may be obtained by inverting all 7 test bits; e.g., the 7/7 output would then be true if no original bits were in agreement.

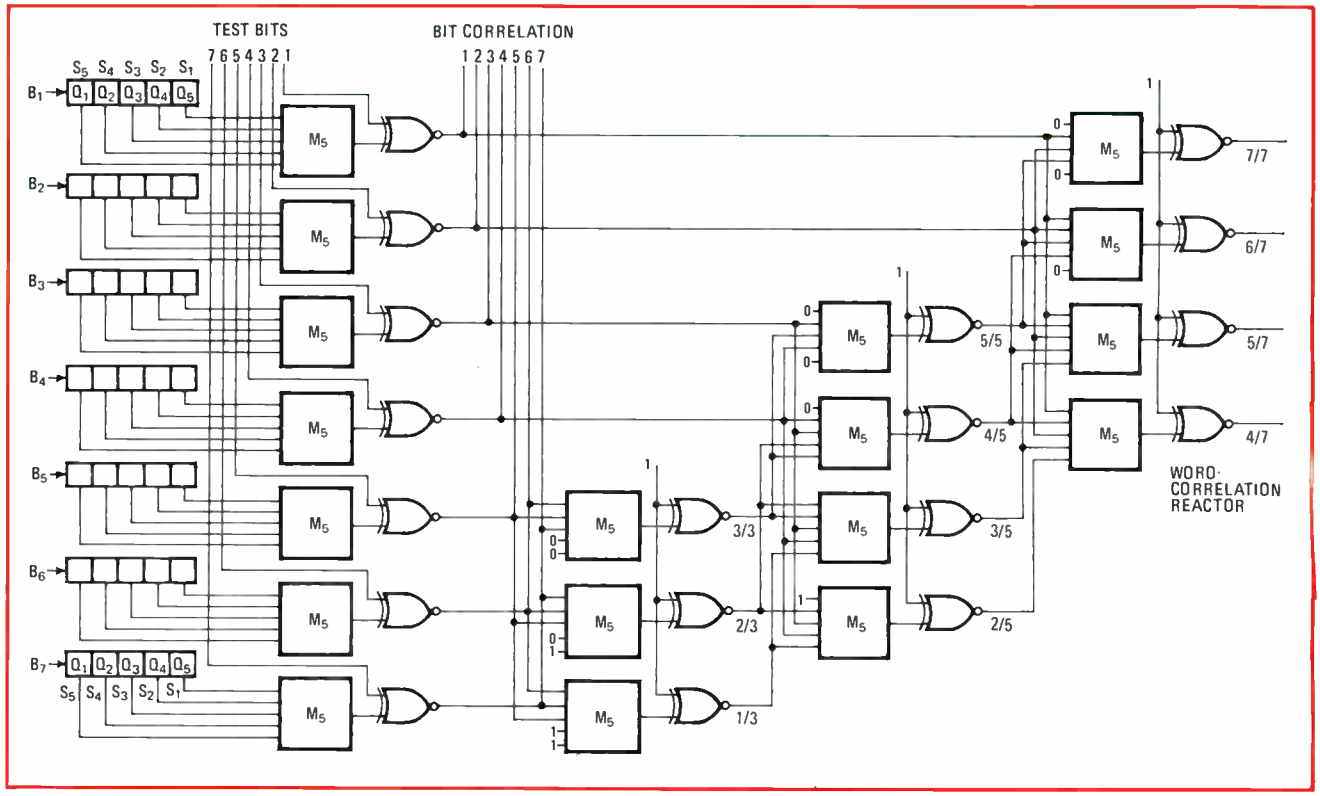


8. In general. General-purpose arrays can be formed to detect n/m possible cases; (a) shows the configuration for 7 bits, which uses 15 M_5 gates (7½ packages). For an encoded output, a priority encoder (b) is used to get the exact number of true bits in an input word; here the output of the array is encoded into a 3-bit binary word.

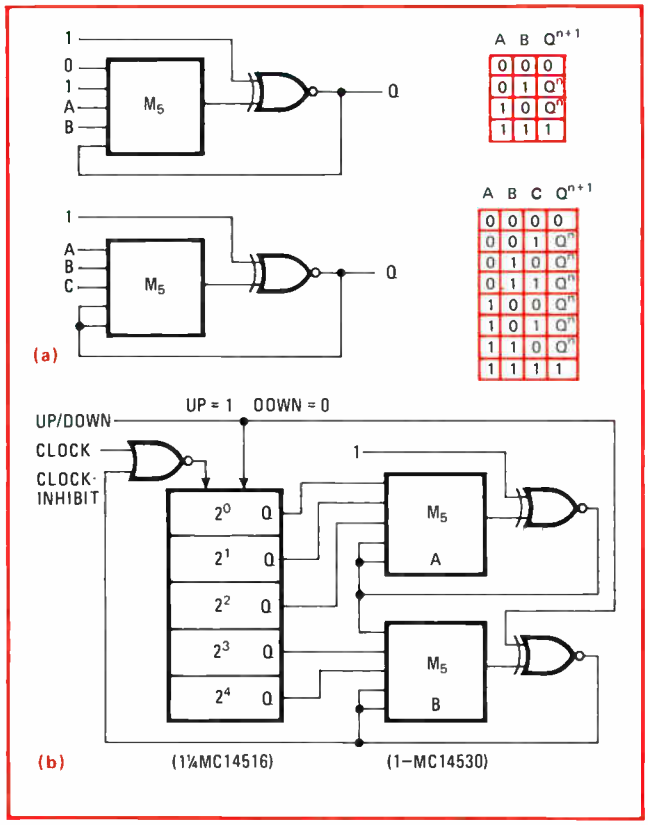
In addition to performing combinational logic with M_5 gates, sequential logic can also be implemented by feeding the output of a majority gate back to one or more inputs. Figure 10a illustrates this application for both three-input and five-input configurations. As the truth tables show, this type of flip-flop will change states only when there is coincidence of all inputs. For changing inputs, the device will hold the state of last coincidence until the opposite coincidence occurs.

One area where this scheme is useful is in the control of UP/DOWN counters. Frequently, when a maximum or minimum count is reached, further counting must be inhibited to prevent spillover—the counter will change all states (all 1s to all 0s, or vice versa). An example is shown in Fig. 10b, where the dual M_5 gate detects all 0s or all 1s, for a 32-state UP/DOWN counter.

The first gate, A, senses whether all 1s or 0s are present from the first 3 bits of the counter. The output of gate A feeds back to two of its inputs and one of the



9. Correlation is the thing. In this 7-bit five-sample correlation array, the first seven M_5 gates on the left vote on the five data-word samples S_1 through S_5. The majority state of the five samples of each bit is then compared bit by bit with a test word (test bits 1–7). The over-all correlation factor is sensed by the 11 gates on the right, which sense 4 out of 7 to 7 out of 7 bits in agreement with the test word.



10. In sequence. Sequential logic is possible with majority gates by feeding the output of a gate back to one or more inputs. Three-input and five-input configurations are shown in (a). In (b), the dual M_5 gate detects all 0s or all 1s for a 32-state UP/DOWN counter.

inputs of gate B. Only when the remaining two stages of the UP/DOWN counter agree with the output of A can the output of B change.

If the counter is in the UP mode (1 on the control line), and a maximum count is obtained (all 1s), the output of gate B will be a 1, inhibiting the clock and thus preventing further counting. On the other hand, if the mode control goes low while the clock is still high, counting will occur downward on the next clock edge, until all 0s result. The counter will then be inhibited again, thus preventing roll-over.

The future of majority logic

Now that majority logic has become economically practical through MSI, the function may become an industry standard. As familiarity grows, the M_5 gate will be used in applications to reduce package count and provide logic that is programable as a result of its own decisions or external computer control. Correlation arrays that are useful for character and speech recognition are natural applications.

The symmetry of the majority-logic layout, using C-MOS devices, lends itself to high-density packing. By using minimum-geometry devices, large majority-logic-gate arrays of more than 200 gates can be fabricated by means of present production technology. Arrays of this size could easily usher in whole new philosophies in system architecture that would lend themselves to what is sometimes referred to as probabilistic processing, where many variables are not necessarily 100% true but instead may be mixed with noise or have assigned weights or degrees of confidence. □

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Capacitor corrects drift for analog data amplifier

by Charles Walton*
IBM Corp., Systems Development Division, San Jose, Calif.

Inserting a capacitor in the gain control feedback path of an analog data amplifier can provide automatic offset voltage drift correction. The drift voltage is stored on the capacitor and held to ±0.1 microvolt/°C.

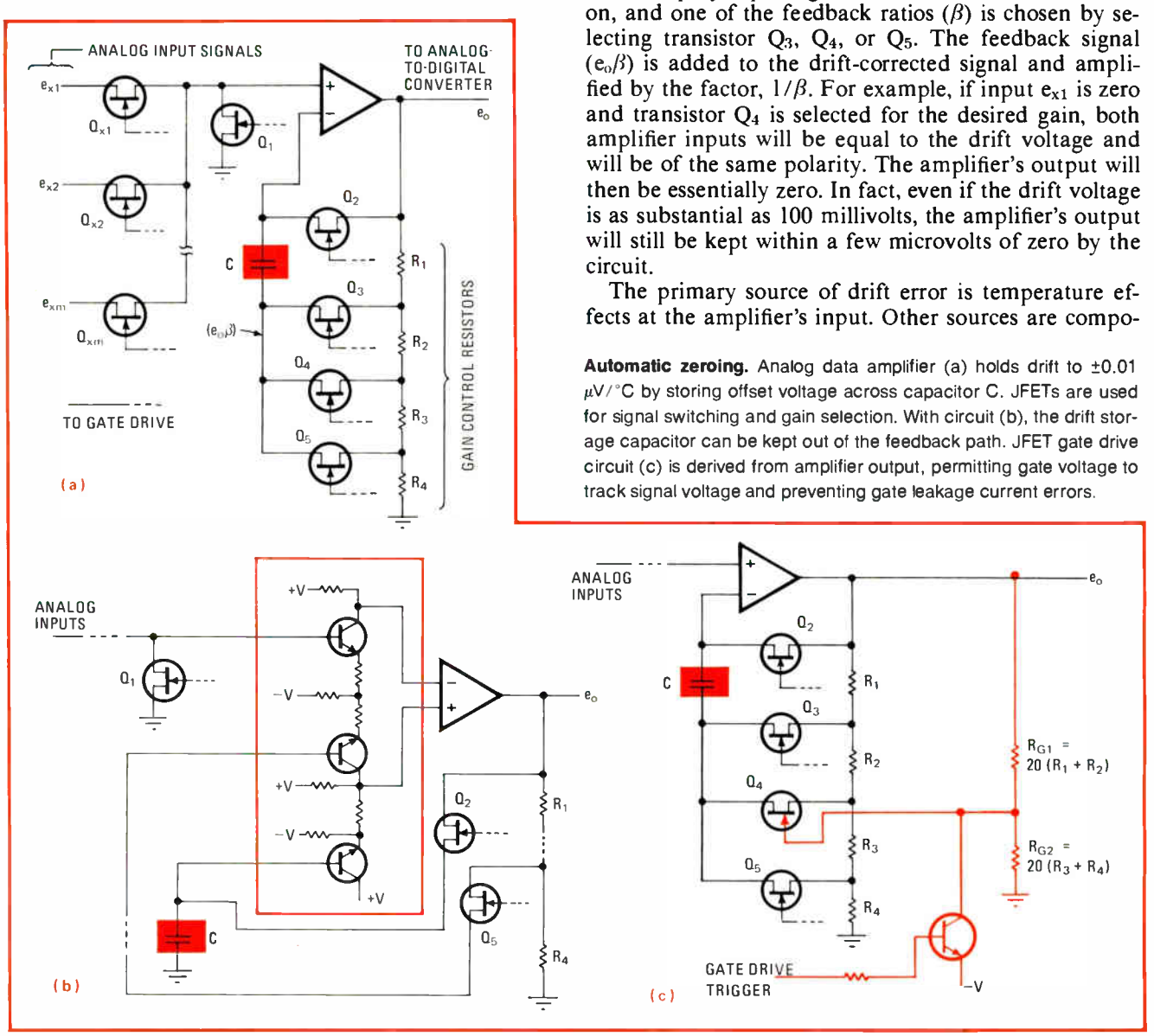
The gain of the amplifier circuit (a), which is intended to operate in conjunction with a multiplexer, is selectable. Junction field-effect transistors are used to implement the gain control. Their gate voltage is provided by a resistor network that allows the gate voltage to track the signal voltage so that errors due to gate leakage current are eliminated.

Between multiplexing cycles, transistor Q_1 conducts, grounding the amplifier input, and transistor Q_2 also conducts, making amplifier gain equal to unity. As a result, the amplifier's dc offset voltage occurs at its output, as well as at its positive input and at the top of storage capacitor C. The other side of the capacitor may be grounded. Or, if resistor R_4 is relatively small compared to the sum of the other feedback resistors, R_1 through R_3, as is usually the case, then turning on transistor Q_5 effectively grounds capacitor C. The capacitor behaves as a battery during the ensuing amplifier cycle. Its value is not critical, but should be reasonably large.

To amplify input signal e_{x1}, transistor Q_{x1} is turned on, and one of the feedback ratios (β) is chosen by selecting transistor Q_3, Q_4, or Q_5. The feedback signal ($e_o\beta$) is added to the drift-corrected signal and amplified by the factor, $1/\beta$. For example, if input e_{x1} is zero and transistor Q_4 is selected for the desired gain, both amplifier inputs will be equal to the drift voltage and will be of the same polarity. The amplifier's output will then be essentially zero. In fact, even if the drift voltage is as substantial as 100 millivolts, the amplifier's output will still be kept within a few microvolts of zero by the circuit.

The primary source of drift error is temperature effects at the amplifier's input. Other sources are compo-

*Now with Proximity Devices Inc., Sunnyvale, Calif.



Automatic zeroing. Analog data amplifier (a) holds drift to ±0.01 μV/°C by storing offset voltage across capacitor C. JFETs are used for signal switching and gain selection. With circuit (b), the drift storage capacitor can be kept out of the feedback path. JFET gate drive circuit (c) is derived from amplifier output, permitting gate voltage to track signal voltage and preventing gate leakage current errors.

nent aging, power supply variations, and the offset of subsequent amplifier stages. But all these effects are slow compared to the amplification cycle time (200 microseconds, in this case). Therefore, the data system simply needs to adjust the stored capacitor voltage between amplification cycles or between a group of amplification cycles.

Placing bipolar transistors at the amplifier's input, as shown in (b), permits the correction capacitor to be kept out of the feedback path. (In most applications, this is only a minor advantage.) When transistors Q_1 and Q_2 are on, the amplifier places a voltage on capacitor C so that the next amplification cycle is automatically corrected for drift.

JFETs are used here for gain control, multiplexing, and zeroing, rather than MOSFETs, because they have more predictable control characteristics, need smaller switching voltages, and cost less. Possible errors due to JFET gate leakage currents can be avoided by utilizing the gate drive circuit of (c).

When a JFET is conducting, its gate voltage need only be within about 0.3 volt of its drain and source voltages. If the gate voltage is slightly less than this, there is a small increase (for an n-channel JFET) in the drain-source resistance. If the gate voltage is slightly higher, the silicon-diode characteristic of the gate-source junction prevents any error-sized current from flowing.

The gate drive circuit shown meets these JFET gate voltage requirements by employing the amplifier output to drive the gates, thereby allowing the gate voltage to track the input signal. In the figure, the gate voltage for transistor Q_4 is obtained from the voltage divider formed by resistors R_{G1} and R_{G2}. These resistors do not have to have tolerances as tight as those of the feedback resistors (±5%, as against ±0.02%).

The high impedance of the gate drive resistors avoids loading the amplifier output. There is a pair of divider resistors for each value of gain. To turn off a gain control transistor, a bipolar transistor is turned on, holding that JFET's gate voltage sufficiently negative to keep it off for all signals. Junction gate leakage current is typically below 100 nanoamperes, minimizing the possibility of errors.

General-purpose JFETs can be used for the amplifier circuit—ones having a source-drain resistance of 50 to 200 ohms. □

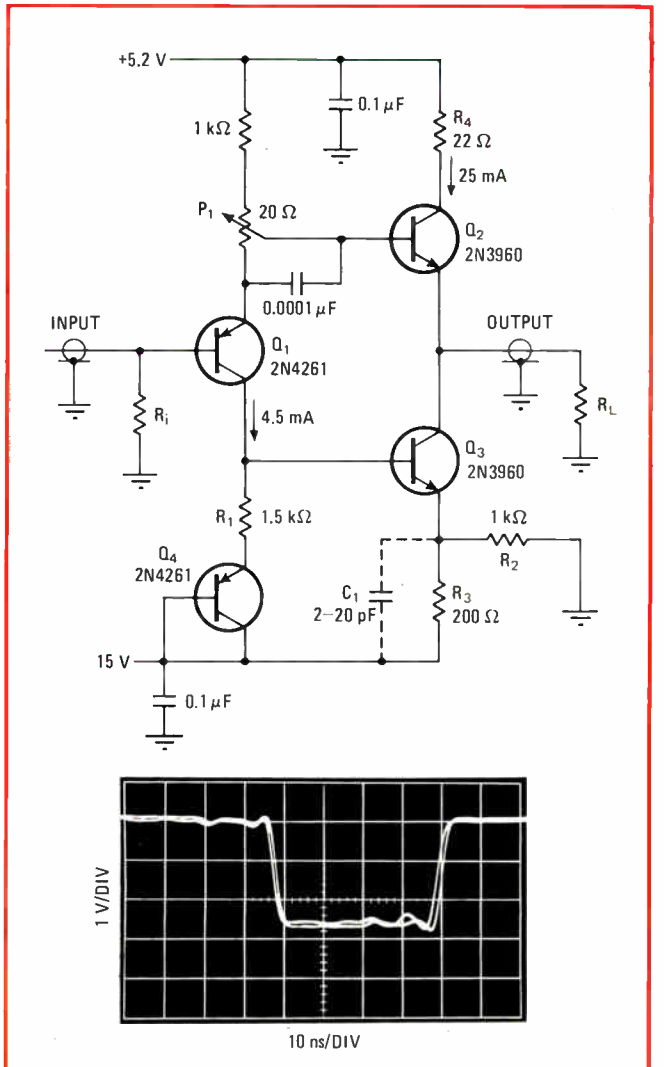
High-speed voltage-follower has only 1-nanosecond delay

by O.A. Horna
COMSAT Laboratories, Clarksburg, Md.

When a voltage-follower is needed for isolation and/or impedance transformation in fast analog circuits, a simple emitter-follower can be made to give better performance than an integrated operational amplifier. A dual complementary emitter-follower overcomes the disadvantages of the conventional emitter-follower—its input-to-output offset voltage and its relatively low voltage gain. Propagation delay for this complementary circuit is less than 1 nanosecond.

The first emitter-follower, pnp transistor Q_1, drives a second emitter-follower, npn transistor Q_2, so that the offset (emitter-base) voltages of these transistors are opposite in polarity. The dc voltage difference between input and output terminals is therefore very small and can be adjusted to almost zero with potentiometer P_1. Transistors Q_1 and Q_2 should make good thermal contact with each other to compensate for the temperature dependence of their emitter-base voltages.

Output transistor Q_2 is loaded by a variable current source, npn transistor Q_3, the base of which is connected to the collector of transistor Q_1. For a given bias current



Fast emitter-follower. Back-to-back emitter-followers, transistors Q_1 and Q_2, are complements, causing their opposite-polarity offset voltages practically to cancel. (Potentiometer P_1 permits fine offset zero adjustment.) Transistor Q_3 is a variable-load current source, while transistor Q_4 is wired as a diode for Q_3's temperature compensating. Scope display shows superimposed input and output signals.

(25 milliamperes here), transistor Q_2 can then deliver nearly twice as much current to the load as would be possible with a constant-current source. The last transistor, Q_4, is connected as a diode to temperature-compensate transistor Q_3's emitter-base voltage.

When the input voltage goes positive, the emitters of transistors Q_1 and Q_2 also become positive. The current through transistor Q_1 decreases, dropping the voltage across resistor R_1 as well as the current through transistor Q_3. The opposite action occurs for a negative input.

The voltage gain of transistors Q_1 and Q_3 can be made greater than unity (between 1.1 and 1.2) by adjusting the resistance ratio of resistor R_2 to resistor R_3. This compensates for the voltage gain of transistors Q_1 and Q_2, which is less than unity (between 0.9 and 0.95). With an unloaded output, the circuit's total stable voltage gain ranges from 0.985 to 0.995, and the output resistance is less than 1 ohm. (The output is protected against short circuits by resistor R_4.)

The scope trace shows the circuit's input and output voltages superimposed on each other. With a load resistor of 50 ohms and an output voltage of ±2.5 volts, the circuit's propagation delay is less than 1 nanosecond, and the rise and fall times are smaller than 2 ns without overshoot. The maximum voltage swing is ±4 V, the bandwidth is approximately 200 megahertz, and the slew rate is over 2 kilovolts per microsecond.

When the load resistance is less than 200 ohms, the circuit's transient response and the bandwidth can be substantially improved by adding a speed-up capacitor, C_1. However, under a no-load condition, when the load resistance is 500 ohms or more, this capacitor can cause the circuit to oscillate.

All four discrete transistors can be replaced by a single quad package, Motorola's MHQ6001, which contains two pairs of pnp and npn transistors. Since these transistors have a gain-bandwidth product of only 400 MHz, as opposed to 1 gigahertz for the discretes, the circuit's propagation delay and rise and fall times will be three to four times longer.

For the bias currents given in the figure, the dc source resistance, R_i, must be less than 2 kilohms. The circuit's input resistance is greater than 50 kilohms for load resistances of 50 ohms or more. □

Mark/space demodulator employs active filters

by Michael J. Gordon, Jr.
Psynexus Systems, Wilmette, Ill.

If active filters are used instead of LC-tuned circuits, a frequency-shift-keyed demodulator can be made smaller in size and its performance improved. The active filters eliminate the need for bulky and expensive inductors. The circuit is designed for demodulating 110-baud FSK data. It operates in the originate mode, where a mark equals 2,225 hertz and a space is 2,025 Hz.

When a mark is received, filter B, which is tuned to 2,225 Hz, passes the signal while filter A attenuates it. The outputs of the two filters are then converted to dc and compared by an op amp that is operated in its open-loop mode. Since the output of filter B is sampled by the op amp's noninverting input, the circuit's output transistor is kept in saturation so that the circuit loop is closed. When the input frequency shifts to a space, filter A passes the signal while filter B attenuates it, causing the circuit loop to remain open.

To adjust the circuit, an audio signal is applied at the mark and space frequencies, and the desired peak output produced by varying the two 50-kilohm trimmers. An approximate peak-to-peak voltage of 1.2 volts is required from a low-impedance source. □

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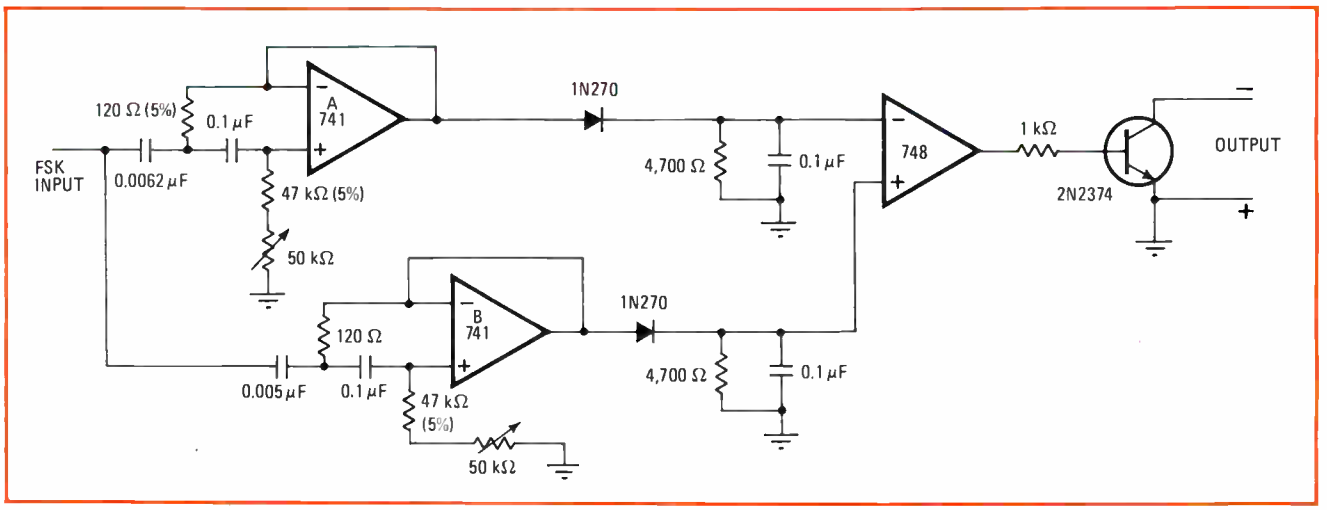
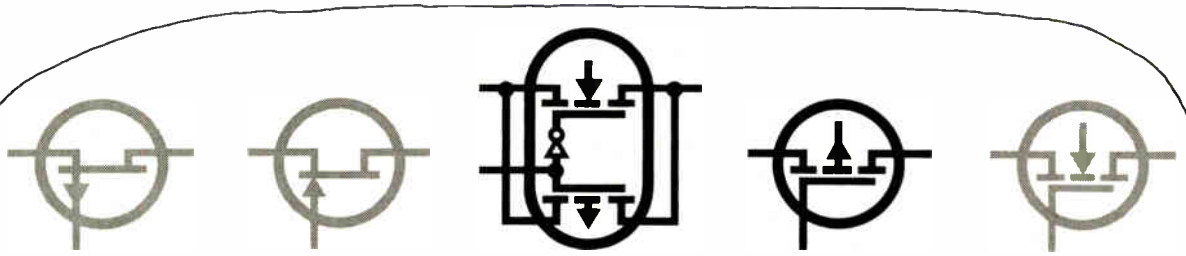


Going active. Frequency-shift-keyed demodulator contains two active filters, saving space and improving performance over designs that use conventional LC-tuned circuits. Filter A passes the space frequency of 2,025 hertz, while filter B passes the mark frequency of 2,225 Hz. The op amp operates open loop, summing the filter outputs. For a mark input, the output transistor saturates so that circuit loop closes.



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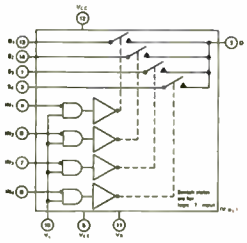

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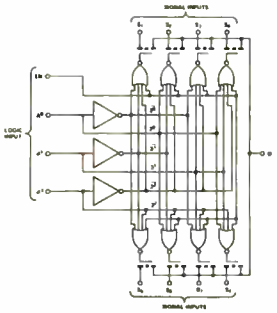

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Part VI of a series

Minicomputers simplify testing of an aircraft's vital functions

Modular processors are adapted to 11 systems that evaluate airplane structures and subsystems, ranging from propulsion capabilities to utility of instrument panels—from design through production phases

by Donald J. Bernitt, *Boeing Co., Seattle, Wash.*

☐ Minicomputers are being used as the data-acquisition and data-processing components of modular systems for testing aircraft structures and systems—from research through hardware evaluation. Inexpensive, flexible minicomputers conserve the large sums of money involved in the design and fabrication of aircraft, despite the complexity of many of the test procedures. Although the minicomputer may seem to be too small for data acquisition or instrumentation on such a scale, it is adequate if it is part of a system that is modularly designed for quick hardware-interface modification and for programing oriented to instrumentation engineering.

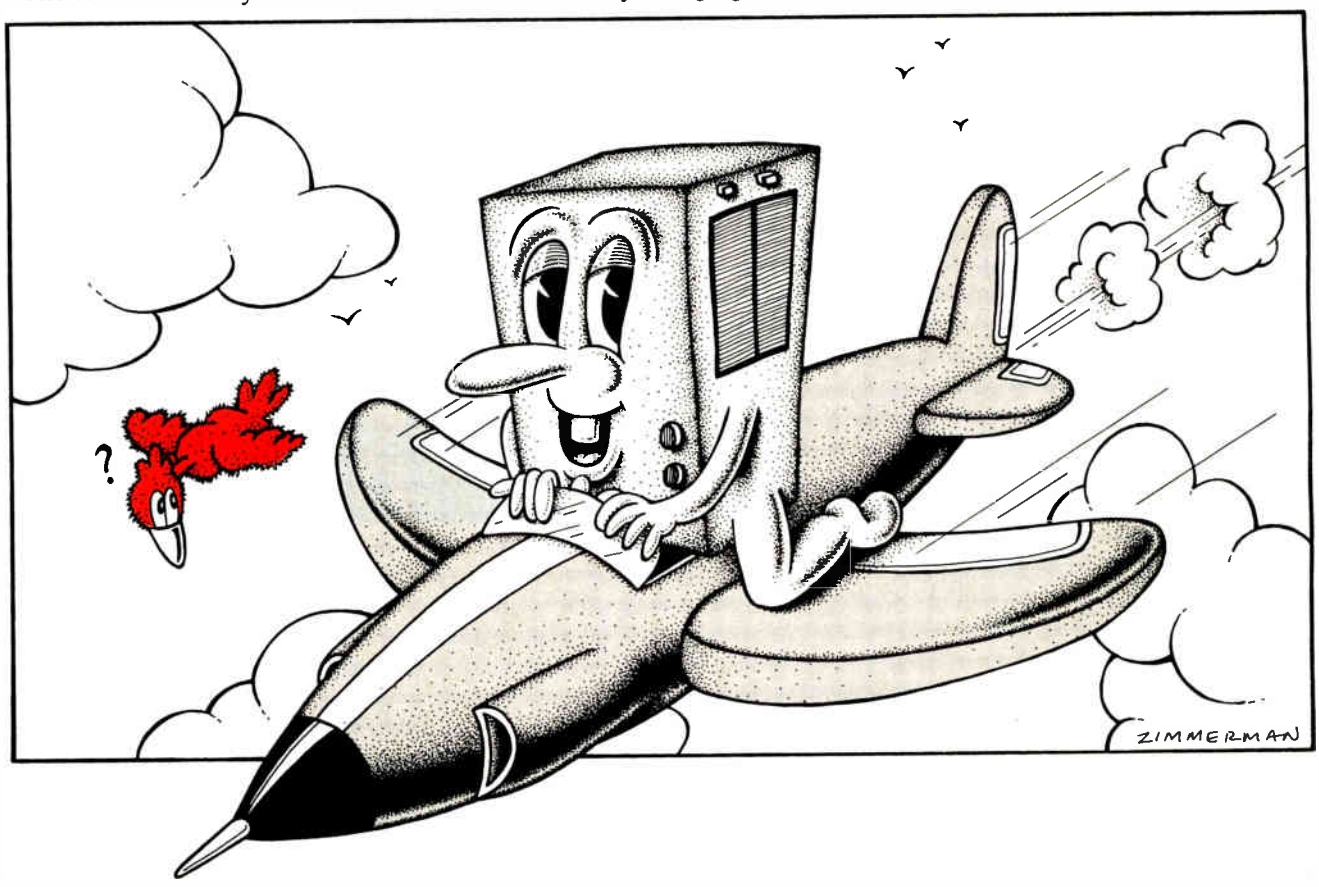
At the Boeing Co., the tests are performed, for the most part, on subsystems, rather than on complete aircraft. Evaluations must be conducted on the structure, electrodynamics, propulsion, flight controls, and such internal systems as electric power and hydraulic actuators.

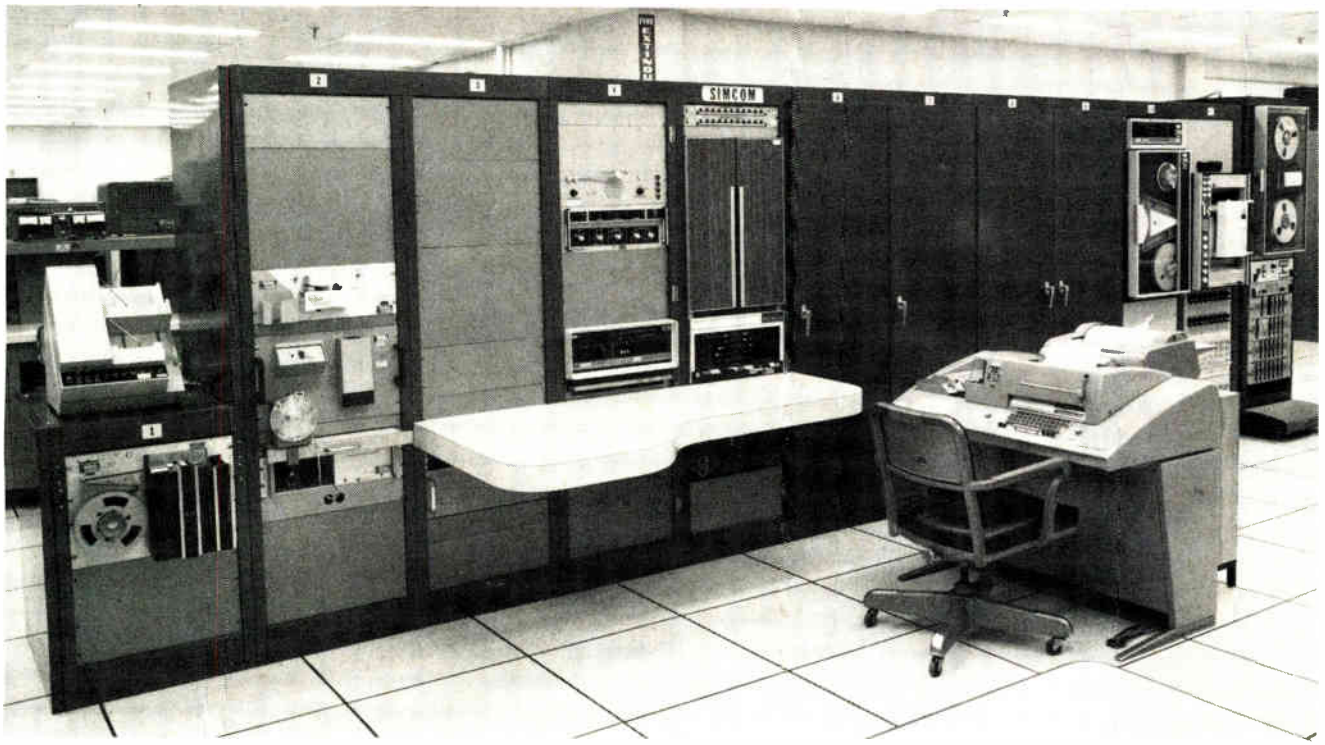
The staffs that carry out the tests are concerned only with the technology of their respective tests—not with manufacturing or any particular type of aircraft. And each staff has its own laboratory—wind tunnels, engine-test stands, static and fatigue-test fixtures, and flight-control simulators, to name a few.

An instrumentation group designs the measurement equipment required in each application, and its personnel operate the data-acquisition systems for all the staffs. Within the group, a data-systems organization develops, designs, and operates the minicomputer-related functions.

Boeing chose the Digital Equipment Corp. PDP-8 for its test systems because of the minicomputer's size, capability, cost, and performance reputation. Over the past several years, 11 computerized test systems have been developed, ranging from structural testing assignments to instrumentation development.

The latest in the line of evolution is Simcom (Fig. 1). In operation for 24 months, Simcom represents the salvaging of a substantial investment in test equipment





1. Simcom. This system, the basis for many instrumentation and testing tasks at Boeing, is easily modified for different projects. It is built around the PDP-8 computer (center, under the Simcom sign). A positive-logic converter adapts it to newer interfaces.

that had been built for a project that was cancelled. The system has been designed for a broad range of test functions, including the monitoring of engine performance in a remote test facility and evaluation of automatic landing-control systems, inertial navigation systems, electric-power systems, and electronic filters for control systems.

The key to Simcom's adaptability is a positive input/output-bus converter that has been added to the PDP-8. This converter adapts positive-logic hardware interfaces for use with the original negative-logic machine, which is now seven years old.

Case studies

Simcom's versatility can perhaps be illustrated best by four case histories.

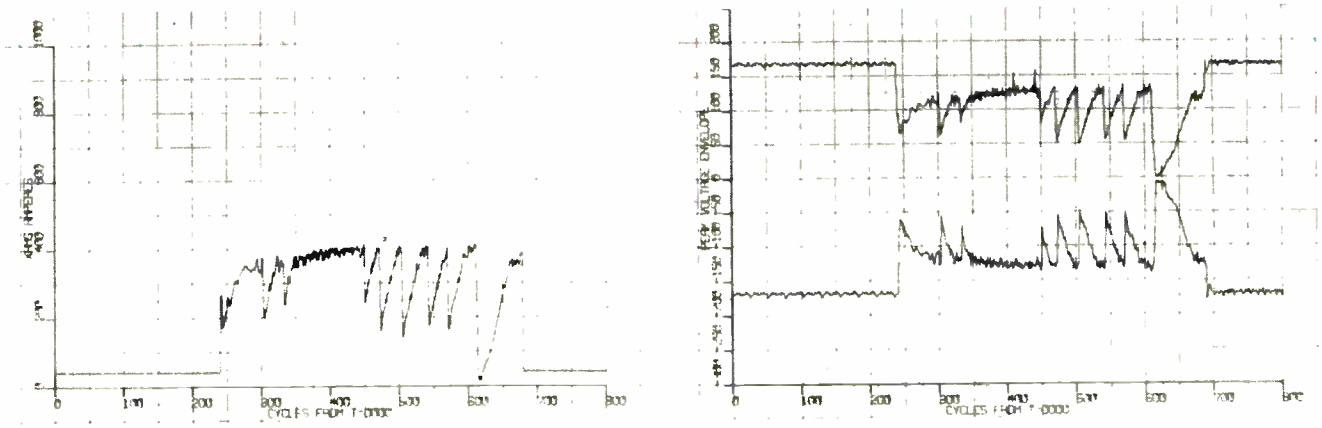
Case I: Evaluating electronic filters and servomechanisms requires tests to be run under varying dynamic conditions. Typically, such an evaluation requires a Bode plot, which gives the frequency response of the filter in terms of both amplitude ratio and phase angle of input and output signals.

Three Boeing engineers, F. Reichlin, R. Swartz, and C.J. Masreliez, invented a Bode interface for the PDP-8, together with the necessary software. Their interface generates an input frequency, digitizes as many as four output responses, and computes the amplitude ratios and phase angles—all in real time. The Simcom setup has made hundreds of Bode plots in various on-line dynamic tests. The minicomputer can also work off-line from analog tapes, provided that certain special recording techniques are used when making the tape.

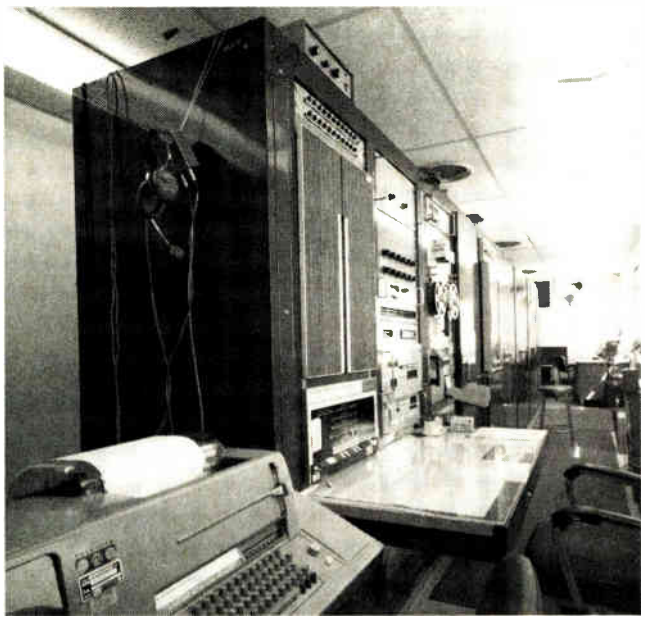
Case II: During 1971 and 1972, a series of flight tests were performed to investigate several different technical approaches to aircraft automatic landing-control systems and inertial-navigation systems. Data from the automatic-landing tests was recorded on analog magnetic tape using conventional fm techniques, and iner-

COMPUTER SYSTEM MUTATIONS

Feature	1968 – 69 MST No. 3	1970 – 71 SST flight-controls development	1970 – 72 Simcom
Hardware multiply/divide	Yes	Yes	Yes
High-speed PT punch	Yes	Yes	Yes
High-speed PT reader	Yes	Yes	Yes
Digital magnetic tape (IBM compatible)	Yes	Yes	Yes
Core size (words)	12,288	16,384	24,576
Disk storage (words)	3,072 to 32,768	3,072 to 32,768	3,072 to 32,768
Card reader	No	Yes	Yes
Data-acquisition channels	2,000	50	16
Sampling rate (per second)	480	27,500 (multiple sub-commutation)	15,000
Digital resolution	15-bit binary	15-bit binary (direct memory access)	12-bit binary
Phone-line interface modem	No	No	Yes
Digital plotters	8	6	1
Language level	Machine language	Machine language	Focal Fortran IV
Program library	Paper tape	Punch card	Magnetic tape



2. Power-system analysis. The double trace represents the peak-voltage envelope and the single trace the rms amperes under short-circuit conditions in a three-phase variable-speed constant-frequency electric-power system for an airplane. Simcom made hundreds of these tests in only three months, whereas with conventional techniques, only a few dozen tests could have been made in that time.



3. Trailer load. One of two mobile test systems evaluates aircraft structures at various sites near Seattle. The system is based on a PDP-8 minicomputer, visible in the foreground.

tial-navigation digital data at 10,000 bits per second on identical analog tape recorders in a direct digital recording mode. Both tapes were analyzed by Simcom at the end of each day's testing. Simcom's analysis was carried out in three steps:

First, it searched the analog tape for selected test conditions. Second, it sampled 13 analog channels of data, acquired under the given conditions, digitized them at intervals specified by its program, integrated selected data, calibrated the channels, time-correlated the data, and added time information that was accurate to the nearest millisecond. Then it wrote the results of this analysis on a digital tape for further processing by a Control Data Corp. 6600 computer.

Third, working with the digital inertial-navigation data, Simcom corrected the pulse shapes and time skew across the serially recorded tracks, buffered the serial data into parallel code, added timing information, and wrote the results on another digital tape for the CDC 6600. Simcom also printed selected navigation parameters for a preliminary analysis.

Case III: By connecting Simcom through telephone lines to a rented teleprinter and modem at an engine-testing facility in Boardman, Ore., about 300 miles from Seattle, engineers are now making computations during each test run within minutes after completion of tests. Simcom computations involve multiple measurements, transducer characteristics, engine-performance equations, and calibrations.

The testing process has been substantially improved by the prompt reduction of data, which had formerly been recorded by a data logger on paper tape that had to be physically carried to Seattle for processing. The remote hookup enabled paper tape produced by the data logger to be transmitted immediately to Simcom, and selected interim computations were transmitted back to a teleprinter at Boardman within about two minutes.

As a side benefit of the remote setup, complete test data can be printed out in Seattle, and magnetic tapes storing images of the line-printer data are made. From these tapes, microfilm records are generated later.

Before the remote arrangement, none of the results were available to the engineers at Boardman until at least a day after the tests, or at least until the paper tape could have been processed by a computer in Seattle—leaving test personnel without guidance for further tests until processing results could be returned.

Simcom, its telephone lines, and remote teleprinters have also been used for other tests in other locations so that mid-test decisions, which were not possible before, can be fed back into the testing process. Simcom must be dedicated to each specific test because it does not have a time-sharing capability. The engineers on each project develop the necessary programs in Focal, the DEC conversational computer language.

Case IV: Analysis of the performance of electric-power systems is also being speeded up by Simcom. Hundreds of such tasks were performed with the mini-computer-controlled system over a three-month period—a task that would have taken years if conventional techniques had been used. Test data is recorded on

Rising from the ashes

Simcom's background shows how a good design can help save a computer system from obsolescence, even when it has been put together from hardware that does not reflect the latest state-of-the-art. Simcom was designed and built as Boeing's third mobile system, MST3, modularly designed with some off-the-shelf vendor equipment and some specially built equipment, plus Boeing system engineering and programing.

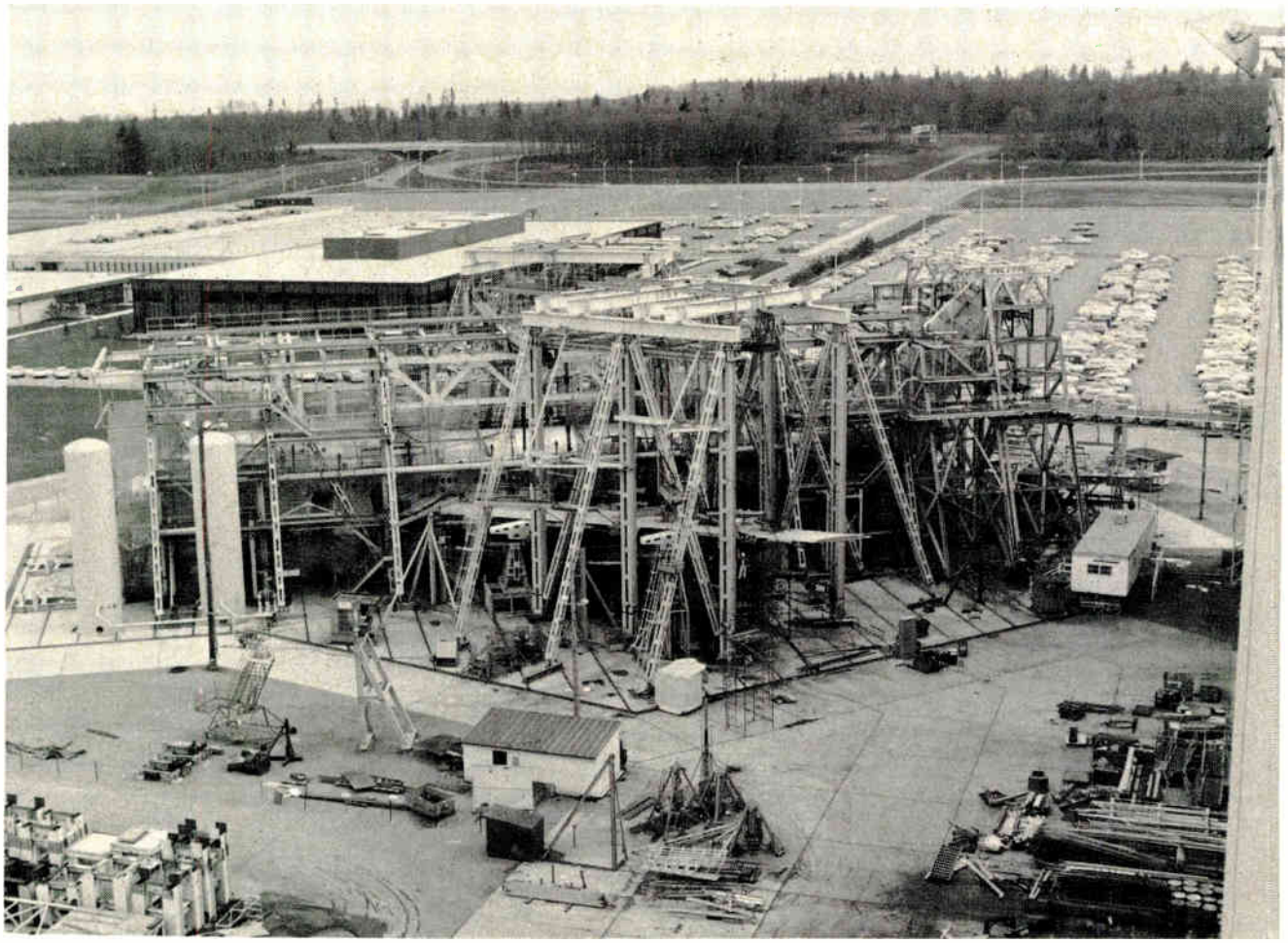
This modular design is widely used today in many minicomputers, both within the processor and in the system as a whole. In particular, the more recent versions of the PDP-8 are modular, so that individual circuit cards, memory sections, input-output controllers, and the like, can be unplugged from the system without affecting its operation beyond the capability of the removed module.

But although the original PDP-8, vintage 1965, wasn't built under a modular concept, its architecture didn't prevent Boeing's technology department from using the computer as one module in MST3, together with twice as many channels as were available in MST1 and MST2 and eight plotters instead of four.

The MST3 was used for a year to acquire data from static structural tests of the 747 (before the dynamic fatigue tests described in this article were begun), and then graduated to the ill-fated supersonic transport program, where it was to be used in developing flight controls for the SST.

This new requirement seemed to demand the capabilities of a medium-size dedicated computer, rather than a minicomputer, but a study of cost versus performance requirements and the prospect of the capital investment that a new "midicomputer" would require produced a decision to rework the MST3 for the SST. The new integrated system included selected components of MST3, some specialized Boeing-built hardware, additional vendor-supplied hardware, and new software.

But the SST program was terminated just as the hardware for the new test system was complete and before the software had been developed. Following termination came great pressure to sell or otherwise decapitalize all equipment not essential to other ongoing projects. The SST test system might have fallen victim to this disposal process, but its modular design, retained from the MST3, saved it. Only its specialized parts had to be scrapped or sold; from the remainder, like the legendary phoenix, came Simcom.



4. Fatigue test. Hidden within the mass of scaffolding is a full-size Boeing 747, undergoing computer-controlled dynamic fatigue tests. Hydraulic jacks subject the fuselage, wings, and landing gear to stresses similar to those encountered in actual operation.

analog magnetic tape, along with time-code and calibration standards. This tape is then analyzed by Simcom through a special hardware interface built for the tasks. The system detects positive and negative peak voltages and currents, as well as measuring the time between successive negative-going zero crossings, on a cycle-by-cycle basis (Fig. 2).

Traditionally, engineers have relied on conventional meters and fast chart recorders to evaluate the performance of electric-power systems. During steady and transient test conditions, this equipment is used to measure amplitude, frequency, phase angle, and power factor.

But Simcom is proving its worth in a project for the design of an electric-power system that will provide a constant 400-hertz frequency to all aircraft loads from a generator driven by the airplane's propulsion system. By customary methods, it would be difficult to determine how such a system responds to short circuits and abrupt load changes. Additional information on various power-system tests is contained in the two papers cited in the bibliography.

Perturbations

As shown in the table, the computer on which Simcom is based has undergone a number of significant mutations since 1968. These hardware and software variations are expected to continue as required for new test instrumentation tasks—in most cases, the interface logic will be easiest to change. Changes in software will be necessary only to respond to the requirements of data acquisition, control, and calculation.

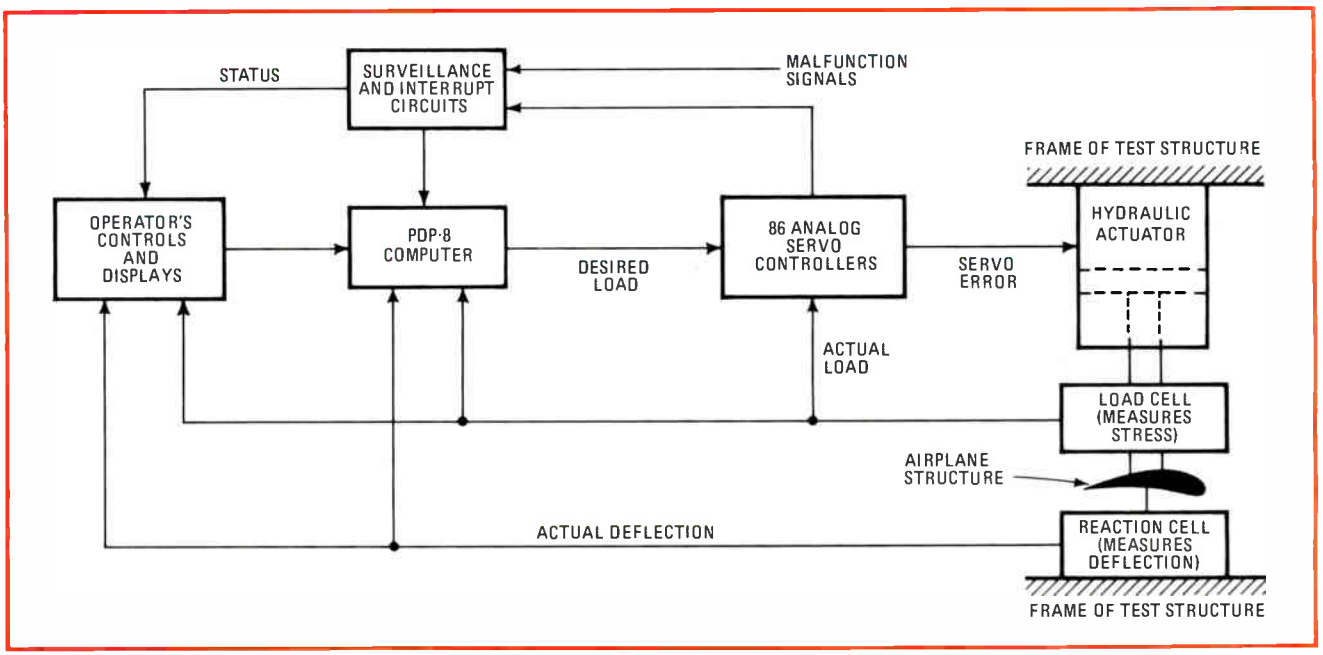
Two of the other 10 minicomputer-based test systems are installed in trailer vans. These mobile units, acquired for structural testing of several different aircraft models, became the basis for the additional systems of today. A third was built specifically to test the structure of the Boeing 747 jumbo jet—the strength and fatigue resistance of its wings, tail, and so on. Two others are used for engine testing in locations that, because these tests are noisy, are remote from Boeing's principal manufacturing and engineering facilities and from residential and other populated areas.

The two test systems in trailers might be considered Simcom's direct ancestors. They are MST1 and MST2 (for mobile structural test), also designed around PDP-8 minicomputers for data acquisition and processing. They log data from nearly a thousand strain gages and thermocouples, which measure impressed loads and structural strains during static tests of full-size airframes, record the digitized readings on magnetic tape, and provide "quick-look" information with a 16-column printer and four digital incremental plotters. For final results, the magnetic tapes are transferred to a large-scale CDC 6600 computer. Because these two systems are installed in trailers (Fig. 3), they can be used at many different sites and are frequently moved within a 40-mile radius of Seattle.

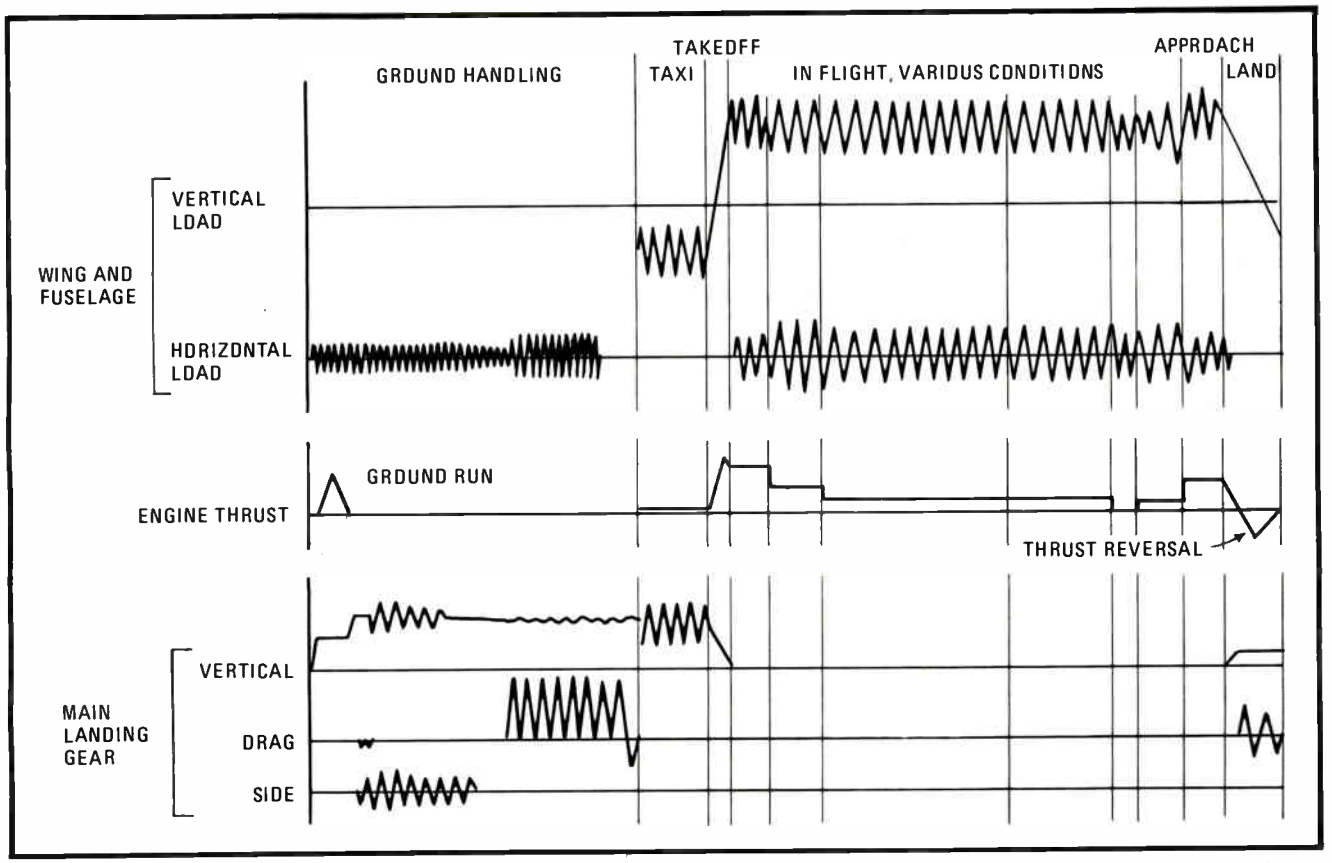
Load is computerized

Full-scale fatigue testing of the Boeing 747 (Fig. 4) was controlled by another PDP-8, part of a load-programing and data-acquisition system designed at Boeing. This system includes 86 channels of closed-loop electrohydraulic load control, which subjects a structually complete 747 airframe to stresses equivalent to three hours of flight in less than 10 minutes. Stresses include those impressed by vertical and lateral gusts of wind, movements of rudder, elevator, and wing flaps during flight maneuvers, taxiing, takeoff and landing, and engine thrust.

Following a sequence specified by the computer program, the computer signals the 86 servo controllers to



5. Fatigue-test control. The tests pictured in Fig. 4 are imposed by a servo system at controlled times, rates, and amplitudes. A computer runs the servos, determines that the actual load equals the desired load, and measures the airframe's response to each load.



6. Test pattern. The full-scale fatigue tests put the aircraft under a wide variety of stresses, a few of which are shown here. Note, for example, the change from negative to positive load on the wings during takeoff, and the reverse engine thrust upon landing.

change the loads they are applying through their actuators to the aircraft. Although the computer can signal any such change in microseconds, to apply such a load would not be realistic because it wouldn't simulate operational stresses, and it could damage the test rig. Therefore the load is changed incrementally along a ramp, with as many as 1,000 steps between a minimum and a maximum load taken over a period of time on the order of milliseconds.

Then, after arriving at a target load, the computer holds that value until the specified load has actually been applied and maintained within an assigned tolerance—that is, until the hydraulic lag intrinsic in the actuators catches up with the specified load. Then the computer scans all 86 channels for a reading of applied loads and resulting deflections, stores the readings, and proceeds to impose another load change.

A block diagram of this control and data-acquisition system is shown in Fig. 5, and a plot of a few representative stresses is in Fig. 6.

The test rig that accommodates the multiplicity of signals encountered in jet-engine testing permits real-time monitoring of the test. This is another data-acquisition system, designed and built by Boeing as the prototype of a series of modular, standardized instrumentation systems.

In the evaluation, many engineering judgments are necessary in real time to permit the test to be conducted in the most useful way. These judgments must be based on combinations of data from a variety of types of transducers, signal conditioners, multiplexers, and data converters. The evaluation is complicated further by the diversity of signals—both analog and digital outputs—from these various sources and by their ranges and coding; the analog signals may range from millivolts to volts or be frequency-modulated, while the digital signals may be pure binary or binary-coded-decimal.

The PDP-8 used in the engine-test rig has 12,288 words in its main memory, plus three magnetic disks that store up to 32,768 words each; the computer presents "quick-look" and final data on a medium-speed line printer (300 lines per minute) and on an incremental digital plotter, and records its output data on punched paper tape.

Remaining test systems, not discussed in detail here, include a five-channel programed controller, an eight-channel program assembler that creates program tapes for a separate noncomputerized controller, an acoustic data-reduction station, an acoustic noise simulator, and an instrumentation development computer. □

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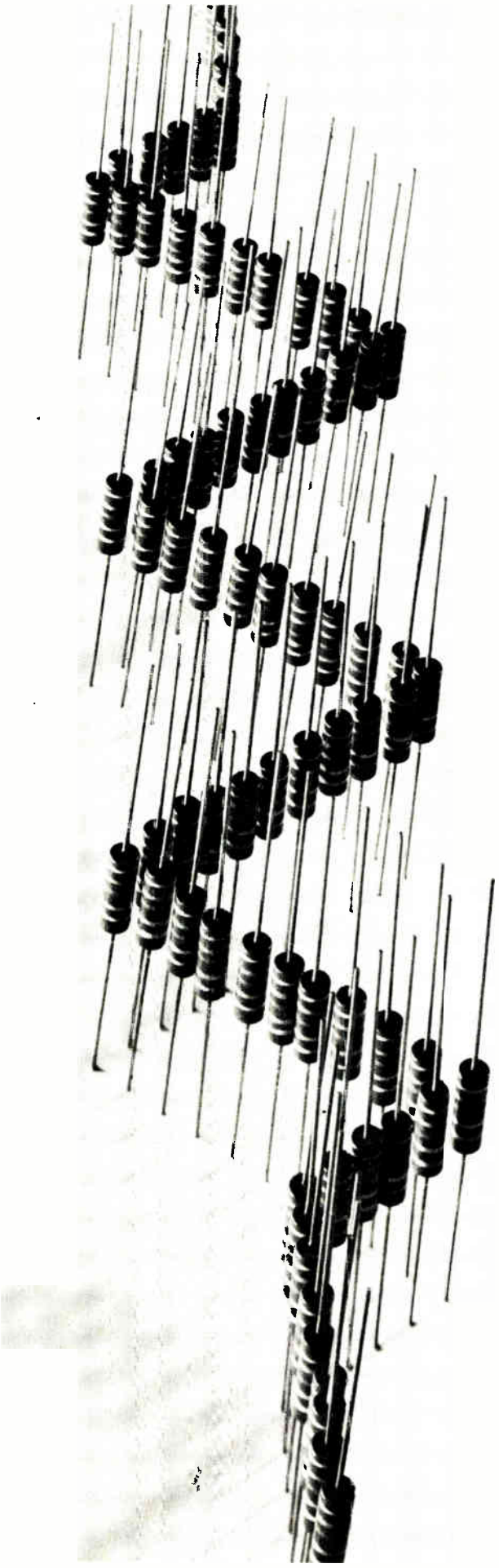

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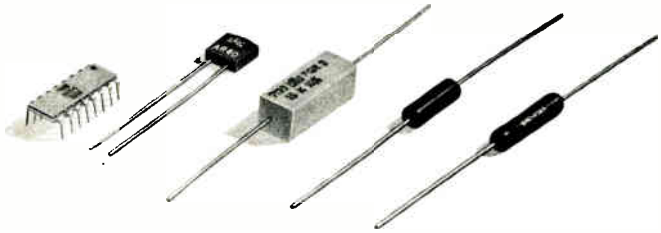

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Checking wired-AND gates in just one test setup

by C.W. Moser, Jr.
Western Electric, Winston-Salem, N.C.

One of the most difficult types of circuits to test effectively is an array of wired-AND logic gates. But a standard design aid, the Mahoney map, can be used to determine the best waveform setup for completely testing such an array.

A typical wired-AND configuration is shown in (a). If only four different waveforms are to be used for testing, the circuit seemingly requires eight test setups and observations of the output to completely verify that it is operating properly. For each of these eight setups, seven of the gates must be disabled, and the gate being tested enabled with the four waveforms.

The wired-AND gates are functionally equivalent to the circuits of (b). The one highlighted in color is actually a circuit that sums logic minterms and has a negative true output. This means that if eight minterms that cannot be reduced through Boolean algebra can be found, the wired-AND circuit can be completely tested with only one setup of the four waveforms by applying all eight minterms to the circuit at once.

A four-variable (A, B, C, and D) Mahoney map (c) can be used to find the appropriate minterms. (The Mahoney map is identical to the Karnaugh map, with the exception of the minterm digits.) The map consists of 16 squares, each one containing a digit that represents the minterm equivalent of that square. Eight of the squares are marked with a colored X; none of these can be reduced with another X-marked square to form a simpler expression.

The logic equation derived from the minterms is:

$$X = m_0 + m_3 + m_5 + m_6 + m_9 + m_{10} + m_{12} + m_{15}$$

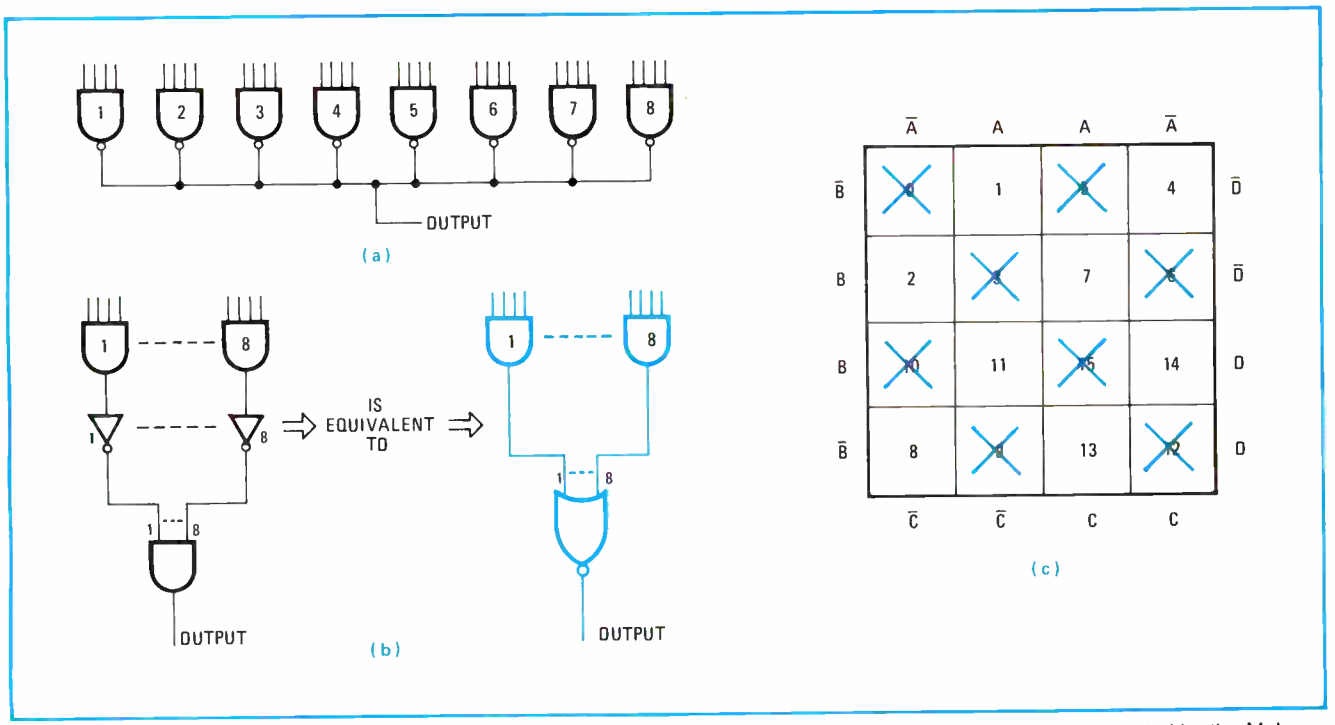
or:

$$X = \bar{A}\bar{B}\bar{C}\bar{D} + AB\bar{C}\bar{D} + A\bar{B}C\bar{D} + \bar{A}BC\bar{D} + A\bar{B}\bar{C}D + \bar{A}B\bar{C}D + \bar{A}\bar{B}CD + ABCD$$

By applying this equation to the inputs of the eight wired-AND gates, every input and output of every gate can be tested with only one setup of four waveforms and only one observation of the output.

This mapping technique can also be applied to other forms of combinational logic. The only requirement is that the test waveforms be similar to straight binary or Gray-code waveforms.

Moreover, the method can be used to determine whether or not a logic circuit has been completely tested. To do this, the circuit's Boolean equation (or equations if the circuit is complex) is first written as a function of the applied waveforms. This equation is next mapped on the Mahoney map or any other device that will reduce Boolean expressions. If any input can be eliminated, the test is not complete. Then, either the waveforms must be reassigned, or additional setups made that will test the unchecked circuitry. □



Logic testing. Wired-AND gates (a) are functionally equivalent to the circuits of (b). The one in color can be represented by the Mahoney map of (c). The eight X-marked minterms determine the inputs needed to test the gates with only one setup of four input waveforms.

DAC differential linearity: it makes a difference

by Ron Gadway
Burr-Brown Research Corp., Tucson, Ariz.

Though digital-to-analog converters are frequently found in CRT displays or in digital plotting systems, it's not as frequently realized that a specification called differential linearity can significantly affect the converter's output and the resulting display presentation.

In a d-a converter, linearity error is usually called out as ±½ the least significant bit (LSB). There are two ways in which it is often defined: either as a straight line drawn between the end points or as a best-fit straight line drawn between all codes. In either case, linearity error means that the actual output voltage will not vary from the ideal output by more than ±½ LSB.

But don't count on this specification alone to take care of linearity problems. If a d-a converter is linear to ±½ LSB, as shown in Fig. 1, its differential linearity can still vary by as much as 2 LSB from one successive digital input code to the next. Differential linearity can be thought of as the maximum or minimum increment in the converter's analog output for a change between two successive digital input codes (for example, from 1101100 to 1101101).

Figure 2 shows the outputs of two different d-a converters, one having an unspecified differential linearity and the other having a specified differential linearity. Both graphs represent the vector form of the monotonic output that is produced in response to an increasing digital input code. Although both outputs are linear to ±½ LSB, only the converter with a specified differential linearity of ±½ LSB confines all possible linearity errors to ±½ LSB.

In a CRT display application, the imperfections in the output of the converter having an unspecified differential linearity will be visible and, most likely, intolerable. Therefore, when choosing a d-a converter for a display, be sure its differential linearity is specified and meets design requirements. □

FIGURE 1

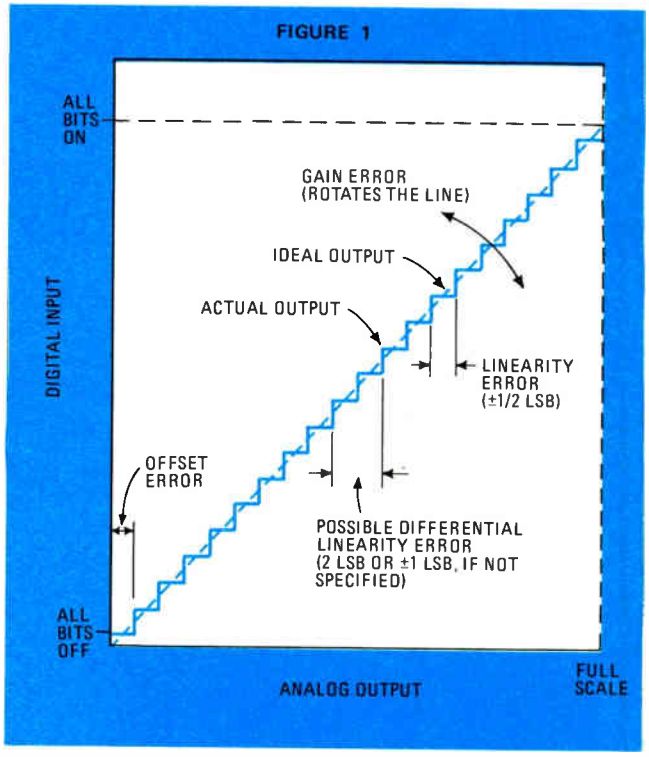
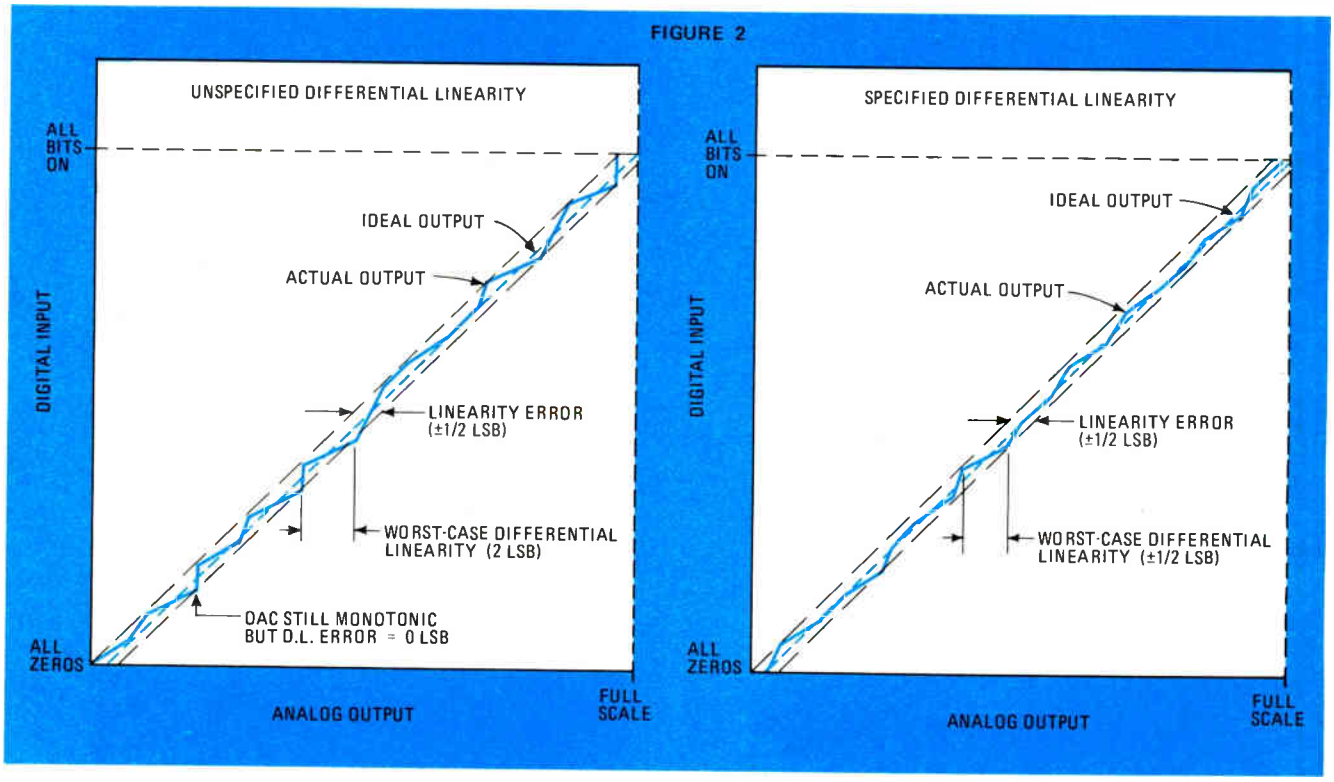


FIGURE 2



Power rating calculations for variable resistors

by Randy Ragan
Mepco/Electra, Inc., San Diego, Calif.

A variable resistor's power rating is influenced not only by the voltage and current applied, but also by the position of its slider and the size of its load. The power rating limits the maximum uniformly distributed power that a variable resistor can dissipate at a given temperature. In effect, the power rating is established by the maximum hot-spot temperature that the resistive element can withstand when the slider is floating. With the circuit labels noted, the maximum unloaded limit can be expressed as:

$$W_{max} = E^2/R_P$$

If the variable resistor is used as a rheostat, the voltage applied across the unit's terminals must be limited to:

$$E_{max} = (1 - K)(W_{max}R_P)^{1/2}$$

where $(1 - K)$ is the smallest fraction of R_P that will remain in the circuit at the minimum resistance setting of the rheostat. The unit's slider current rating must also be respected. For a rheostat, this current is:

$$I_S = E/(1 - K)R_P$$

If the variable resistor is used as a potentiometer and is loaded, the power rating must be reduced because of the disproportionate amount of current drawn through the upper part of R_P and the slider. The degree of derating depends on how large K, the fractional setting, may be. Usually, it is assumed that there is no heat transfer from the more heavily loaded part of R_P to the less heavily loaded part. (This is also true for operation as a rheostat.)

Actually, there are two limitations on power rating when the potentiometer is operated with appreciable loading: power dissipation and slider current rating. The voltage across the upper part of R_P can be written as:

$$E_1 = E[R_P(K - K^2) + R_L(1 - K)]/[R_P(K - K^2) + R_L]$$

This voltage may not exceed:

$$E_{1(max)} = (1 - K)(W_{max}R_P)^{1/2}$$

where W_{max} is the unloaded power rating of the potentiometer. Therefore, the maximum voltage that may be applied to a loaded potentiometer is:

$$E = (W_{max}R_P)^{1/2}[R_P + R_L(K - K^2)]/[R_P + R_L/K]$$

And the current through the slider is:

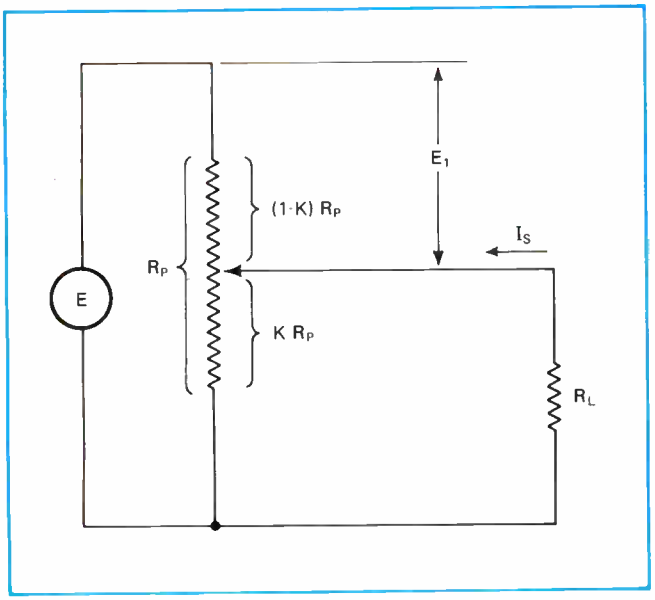
$$I_S = (E - E_1)/R_L = E/[R_P(1 - K) + R_L/K]$$

This value, of course, must not exceed the potentiometer's slider current rating.

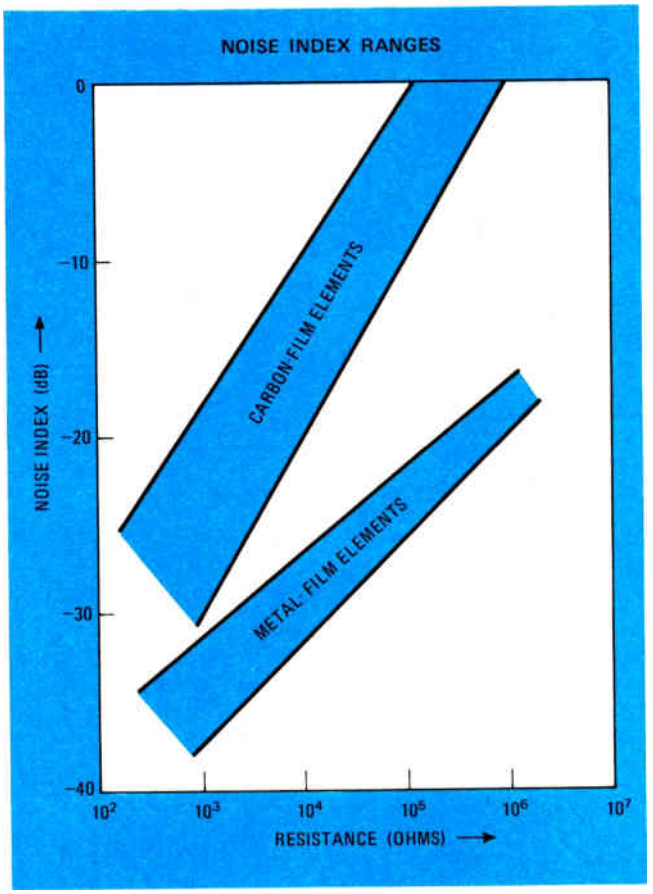
Besides power rating, noise is another important consideration. For a film potentiometer, noise voltage is generally assumed to be generated in the signal-return leg. This voltage, therefore, is in series with the active portion of R_P and the load. (In practice, only a proportional part of the noise is generated by the active part of R_P.)

The interface between the slider and the film element generates a minute voltage because of a thermocouple (Seebeck) effect. This thermal emf is roughly proportional to temperature and can frequently be considered negligible. The graph indicates typical noise performance for carbon-film and metal-film potentiometers. □

Variable resistor. Slider position and slider current rating must be considered when the power rating is being computed.



Engineer's notebook is a regular feature in Electronics. We invite readers to submit original design shortcuts, calculation aids, measurement and test techniques, and other ideas for saving engineering time or cost. We'll pay $50 for each item published.



Why a 12-bit DAC is better than two 8-bit DACs

One snag in digital-to-analog conversion is that you can't improve the resolution by summing the outputs of two DACs. For example, an 8-bit DAC is often less than half the price of a 12-bit DAC, and **two 8-bit DACs would seem to offer a potential resolution of 16 bits.** But a 12-bit DAC produces 4,096 [2^{12}] output levels that will be accurate to within plus or minus half the least significant bit, or ±1/8,192 of full scale. On the other hand, an 8-bit DAC provides only 256 output levels, so that an error of plus or minus half the least significant bit is equivalent to ±1/512 of full scale. This means that **an 8-bit DAC, whether singly or in multiple, will allow errors that are up to 16 times larger than those of a 12-bit DAC.**

Poor common-mode rejection rejected

To get better common-mode rejection from those sensitive instruments equipped with floating inputs and a guard terminal, don't do what is commonly done and short the low side of the input to the guard terminal directly at the instrument. Instead, connect the guard and low-side terminals together at the signal source. This creates **an independent path for the common-mode currents, so that CMRR is improved.**

Jacking, patching made easy

You'll get even **more use out of wire-wrap panels if you exploit the connector potential of the back pins.** These pins, being 25 mils square, are a handy place to jack in and patch—the more so now that Winchester Electronics Group, a division of Litton Systems in Oakville, Conn., will supply mating plugs to fit.

Invisible wafer defects made visible

In complex ICs built on 3-inch wafers, crystal defects are especially costly yield-killers. But you can lessen the problem with a family of **infrared viewers that clip on to any microscope and make it possible to see any defect, however deep inside the wafer.** The viewers, supplied by Electrophysics Corp., Nutley, N.J., are each equipped with an image-converter tube. The magnified defect is focused on its photocathode and then converted into a visible image on a fluorescent screen. The only preparation necessary is to remove a wafer sample from the batch and decorate it with copper that must be diffused at 950°C and then be rapidly cooled.

Time-shared Speedy helps design microwave circuits

Microwave designers can reduce or eliminate breadboarding time by using a time-shared computer program developed by Fairchild. **The program works for a wide range of frequencies**—from 10 megahertz to 12 gigahertz—and includes a data file of S parameters for 24 microwave transistors produced by Fairchild's Semiconductor Components Group, Mountain View, Calif.

Fairchild supplies the program along with a complete instruction manual free of charge; users pay only for computer time on General Electric's nationwide time-shared network. They also need a Teletype terminal connected by phone line to the GE network plus, of course, knowledge of the program, dubbed Speedy. **Happily, no extensive programing experience is needed.**

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S/D or R/D	90V	400Hz
S/D	90V	60Hz

TYPICAL D/S MODULE SETS		
FUNCTION	LINE-LINE	FREQUENCY
D/S or D/R	11.8V	400Hz
D/R	26V	400Hz
D/S or D/R	90V	400Hz
D/S	90V	60Hz

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Raytheon Semiconductor Update

Announcing Monometallic Silicon Nitride Passivated Glassivated Wireless Bonded Semiconductors in conventional packages.

Technically speaking that describes the new Raytheon Semiconductor line of *super-ultra-reliable* transistors and diodes available for the first time ever in standard packages. But we simply refer to them as our SURE products. They're specifically designed for critical applications calling for extremely reliable performance, or for operation under the most severe environmental conditions.

The SURE packaging innovation combines the latest advancements in beam lead technology with assembly techniques that are truly state-of-the-art (and that's not just the usual cliché). In this unique process there are no "flying" wire interconnections between the terminal post and the silicon chip. Instead, external leads for the base and emitter are formed to permit bonding *directly* to the beam leads of the device. Both collector beams are common to and bonded directly to the header.

This means there are two less interconnections than a standard transistor to worry about. Another plus factor: The bonds are the gold-to-gold compression type, well known for their excellent reliability. So you end up with a device that's capable of much higher operating temperatures, higher shock, g's and vibration than comparable die-mounted semiconductors. (And we've yet to reach the ultimate limits in these areas. Not an idle brag, but a fact.)

Actual scanning electron microscope picture of a SURE transistor mounted on the newly developed TO-18 header.

The beam lead chip is, of course, silicon nitride surface passivated. It does not require additional sealing to protect the surface of active silicon from contamination. And if you are a real purist, you can specify beam leads that are glassivated over the metalization.

As you can see in the actual scanning electron microscope picture, the unique, perfectly shaped edges of the chip form a precise 54-degree angle with the vertical. This is a result of Raytheon Semiconductor's exclusive V-ATE process which ensures more accurate, repeatable separation of chips without the inherent stress producing scribe-and-break or irregular etch methods commonly practiced. In this way we can also maintain a thicker, more rugged device with superior thermal characteristics.

At present Raytheon Semiconductor SURE products include bipolar PNP and NPN transistors and switching diodes. They are available in a TO-18 3-lead metal can and a TO-86 14-lead quad-transistor flat pak.

SURE products are without a doubt the highest quality semi-

conductors of their kind ever built. In fact they're so good that maybe *Monometallic - Silicon - Nitride - Passivated - Glassivated - Wireless - Bonded - Semiconductors* is a more deserving name. But for our salesmen's sake if you want more information on Raytheon Semiconductor's new *super-ultra-reliable* transistors and diodes, just ask us for SURE.

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The cover for the new Raytheon Semiconductor linear catalog really says it all: TOTAL LINEARS. That simply means we can fill 9 out of 10 of your needs for linear integrated circuits.

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Many of these linear devices are proprietary with Raytheon Semiconductor. Like the 1556A Beyond Super Beta Op Amp. Or the new 4194 adjustable and 4195 fixed voltage regulators you've probably read about. And the only true Quad 741 High-gain Op Amp; we call it the 4136.

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New Low-level Audio Amp Doubles Battery Life

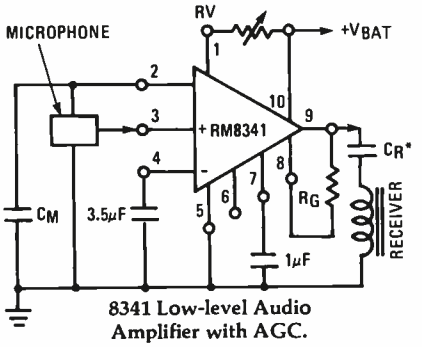
Raytheon Semiconductor is now producing a new low-level audio amplifier that outperforms anything in its class. Designated the 8341, it's ideal in battery powered circuits such as hearing aids, remote microphones, tape preamps, and other milliwatt amplifier applications.

The quiescent current of the 8341 is only 0.5mA. So you'll get twice as many hours from your battery supply than you would with a similar device. The voltage gain is a healthy 70dB — even over a supply voltage range of 1.1V to 1.7V. And the total harmonic distortion is only 1%. What's more, it has AGC with a dynamic range of 30dB.

From a design standpoint, the first and second differential gain stages are biased with current sources that are independent of supply voltage changes. So you can expect less than a 2dB change in gain over the entire battery life cycle. The output stage is a single-ended class AB type to minimize battery current drain. It's also biased to provide a maximum AC output swing of plus or minus one-half of the supply voltage.

With an external resistor you can set the maximum gain below the nominal 70dB level. Or if desired, you can vary the gain by means of an external volume control.

The AGC threshold is adjustable by means of an external resistor, and its transient response is determined by a small external capacitor.



8341 Low-level Audio Amplifier with AGC.

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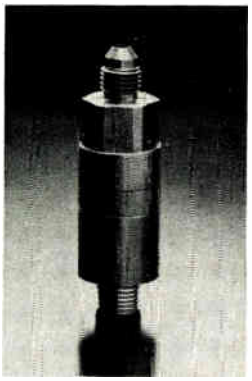

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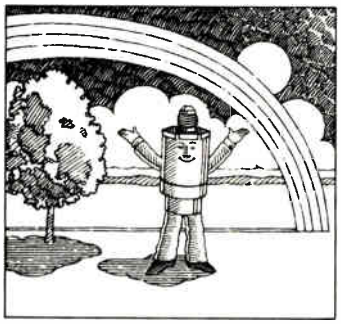
Does that make 4-326 the *best* transducer in the world? In its field. In its range. Within its performance limits, test engineers in every industry say "Yes, it's the best."

Number 4-326 *is* one helluva transducer. A high performance, general purpose, unbonded transducer. With a 40 milivolt output and an uncanny ability to deliver superior performance in environments at temperatures ranging from −320°F to +300°F.



Our transducers get around.

For over ten years, the "Old Pro", 4-326, has been satisfying customers in every field. In every test condition known to man: From below the earth's surface to the outer limits of space.

Yet for every "mister popular" with spectacular credentials, Bell & Howell has quite a number of not-so-well-known transducers with the same bloodline, the same impeccable credentials.

Each of our "lesser knowns" has made it through field-test conditions. Under fire. Under pressure. And each and every one of our transducers has passed the test expected of it by its user.

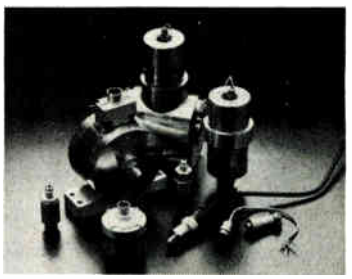
Sometimes we go overboard.

Our transducers are no strangers to unusual environments. Take number 4-366, (also known as "Frogman"). This easy-to-install, easy-to-use, general purpose pressure transducer is totally at home under water. Its polychloroprene/polyolefin cable makes it completely waterproof to 600′ depths.

This little piece offers 40mV direct output, comes in an all-welded stainless steel case, and is salt water compatible. Naturally, it's been factory quality-control tested and comes with a calibration certificate.

We'll go to any extreme.

Airborne missiles and rockets, test stands, aircraft maintenance and control, cryogenics— are the areas where you'll find number 4-356, our high accuracy transducer (0.25%).



Its wide temperature range, all-welded pressure cavity; and heat-treated, stainless steel case and diaphragm, make it impervious to harsh environments including corrosives. With this rugged little 2.5-ounce performer you can be damn sure of superior performance in the areas where it counts: accuracy, durability, size and weight.

Our long suit.

We make more than 400 types of transducers. That's right. More than 400. In every size, shape, mounting configuration, and pressure range.

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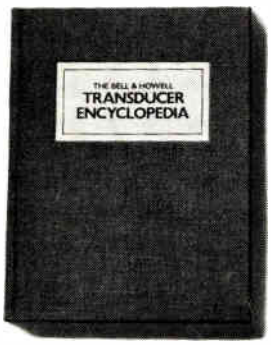
We deliver. And we mean fast.

Perhaps the best news of all is our product availability story. Because, our story is short and sweet: Select any one of the 52 varieties of the 4-326, and we'll ship within 24 hours. To order, call collect, (213) 796-9381.

We're rewriting the book.



It's true. We *are* rewriting the book, the Bell & Howell Transducer Encyclopedia. To be published this fall, it will be the most comprehensive study *ever*. Want to be a contributing editor? We will pay $25 for every article, case history, or personal experience accepted by the editor by Aug. 31, 1973. Write, Encyclopedia, Bell & Howell, CEC/Instruments Division, 360 Sierra Madre Villa, Pasadena, Ca. 91109.

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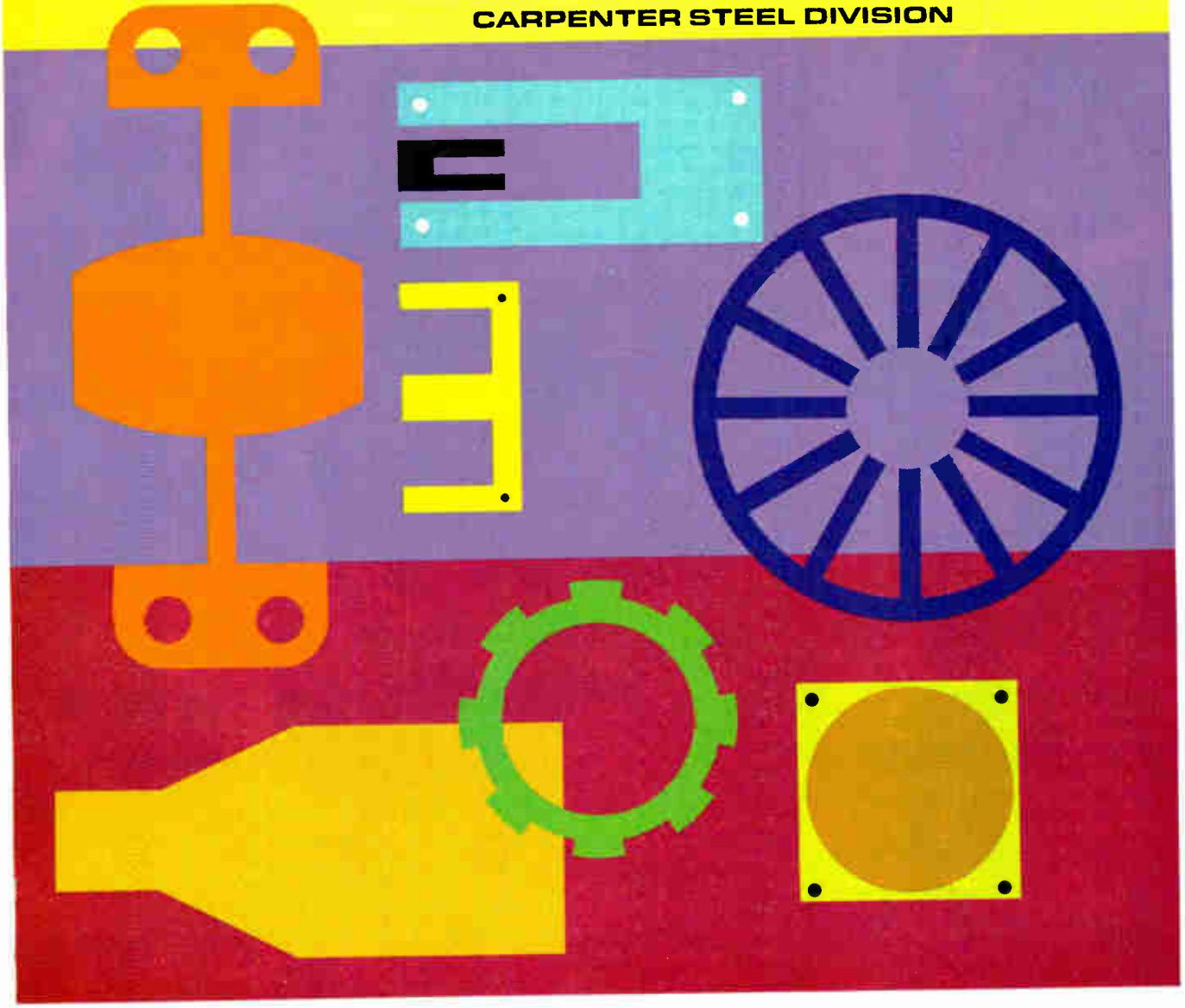
CarTech CARPENTER TECHNOLOGY

CARPENTER STEEL DIVISION



You can change circuitry. Add new functions. Advance performance or improve it. You can develop the whole new system concept you want. Or part of one. You can have it cost far less to produce and far less to service.

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Litton WINCHESTER ELECTRONICS

Circle 136 on reader service card

Counter operates to 1 gigahertz

Top of the line in Dana series is aimed at new land-mobile communications band; family includes four models starting at 50 MHz

by Paul Franson, Los Angeles bureau manager

Best known for its digital voltmeters, Dana Laboratories of Irvine, Calif., is diversifying its instrument-market image with a family of frequency counters, competitively priced units that count as high as 1 gigahertz. The 1-GHz counter, priced at $1,650, counts directly to 250 megahertz, so its internal prescaler needs only to divide by four in order to reach the 1-GHz level.

Older counters used heterodyne techniques, as do higher-frequency units made by Dana's sister company EIP Inc. The 1-GHz ceiling is especially significant because of the opening of a new land-mobile communications band at 900 MHz. This new band will likely set a new plateau for counters, just as the 450-to-470-MHz land-mobile communications band has stimulated production of many counters with 500-MHz ratings.

Dana's new line consists of four units, the 7799 for 1 GHz, the 7750 for 500 MHz, the 7720 for 200 MHz, and the 7705 for 50 MHz. The counters are modular, with the 200-MHz unit adding prescalers and amplifiers to reach the higher ranges. The least expensive unit, the 7705, costs $565. Dana's present counters are relatively high-priced, but James Helfrich, marketing manager, expects the new competitively priced counters to double the company's counter sales within the next year to 18 months.

Because the mobile-communications market is expected to account for a large part of the sales of Dana's new counters, company engineers carefully researched customer requirements before and during development. Arch Conway, counter product manager, says they found that users needed a sensitivity of at least 25 millivolts rms, even at 1 GHz; otherwise, inconvenient external amplifiers are needed.

To be on the safe side, the counters were designed to have 10-mV sensitivity on the 50-ohm uhf inputs for 500 and 1,000 MHz. For the 1-GHz version, a commercial amplifier is used, with a Dana design used for 500 MHz. Like other parts of the circuit, this amplifier design is used in other Dana counters now on the market. The 1-GHz prescaler is a Plessey monolithic emitter-coupled-logic circuit, whereas the 500-MHz divider is a Dana discrete design. Measurements to 10 Hz at 1 GHz require 400 milliseconds; it takes half that long at 500 MHz.

To simplify use of the units, the 50-ohm uhf inputs include automatic gain control with more than 40-decibel range. The agc, again used in earlier counters, employs p-i-n-diode attenuators. "Nothing is more frustrating," says Conway, "than applying a signal to the counter and not have it count properly."

In addition, the agc reduces false counting, which can exist with noise superimposed on a strong signal. If a simple clipper were used, it might detect the noise as a signal. A front-panel in-range light indicates when the input signal is large enough to be counted accurately. If the light is not on, the uhf channel is disconnected, and only the high-impedance, 200-MHz input is enabled. Maximum input to the 50-ohm channel is 5 V rms; optional overload protection is available.

The 200 MHz section of the counter uses ECL in the first decade and transistor-transistor logic in the next decade, followed by a five-dec-

Head of family. The 7799 counts to 1 gigahertz, covering new land-mobile frequencies.

ade MOS chip for the remaining dividers. The first ECL stage is Motorola's MECL III, and MECL 10K is used in the rest of the decade. The 200-MHz high-impedance channel has a manual sensitivity adjustment for maximizing signal-to-noise operation. For general use, 50-millivolt sensitivity is considered adequate, Conway says.

A seven-digit light-emitting-diode display is standard, with an extra digit optional. The power supply in the uhf versions is built from a highly efficient, modular switching design for minimum power consumption. The instruments operate from standard 110- or 220-v supplies. Market research indicates that everyone likes the idea of battery operation, but few have applications worth its cost, as evidenced by lack of a market for suitable batteries.

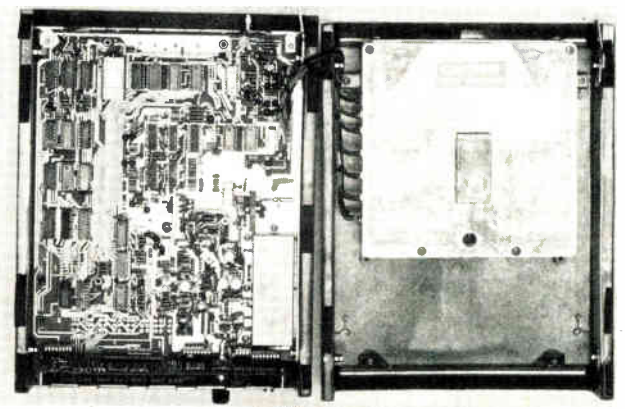
The clock circuit in the counters uses a Mostek eight-decade MOS divider chip. An inexpensive clock oscillator is included, with trimming adjustment accessible from the back. This minimum clock is provided, since many users prefer to maintain their own standards on production lines using many counters, but an optional, high-stability temperature-compensated crystal oscillator can plug inside the instrument if it is needed. Accuracy is to within ±1 count plus the accuracy of the time base.

Accessible. For mechanical assembly of the unit, the top and bottom pieces are identical cast aluminum "clam shells" that are attached by slide latches. The top, which contains the modular power supply, can be removed without any tools, and the conductor side of the single circuit board is accessible by removing a single screw. The counter operates without the cover, and no extender cards or cable are required. All integrated circuits plug in for ease of maintenance. For the lower frequency ICs, sockets are used, with special individual socket jacks for the critical high-frequency ICs.

The counters are 8 inches wide (half-rack), 3½ in. high, and 11 in. deep. They weigh 8 pounds. BCD output is optional. Delivery time is 45 days for the 7705, 7720, and 7750; 60-90 days for the 7799.

Dana Laboratories, 2401 Campus Dr., Irvine, Calif. 92664 [338]

Easy maintenance. "Clam shell" packaging of counter, with power supply in top half of case, makes it easy to service instrument.



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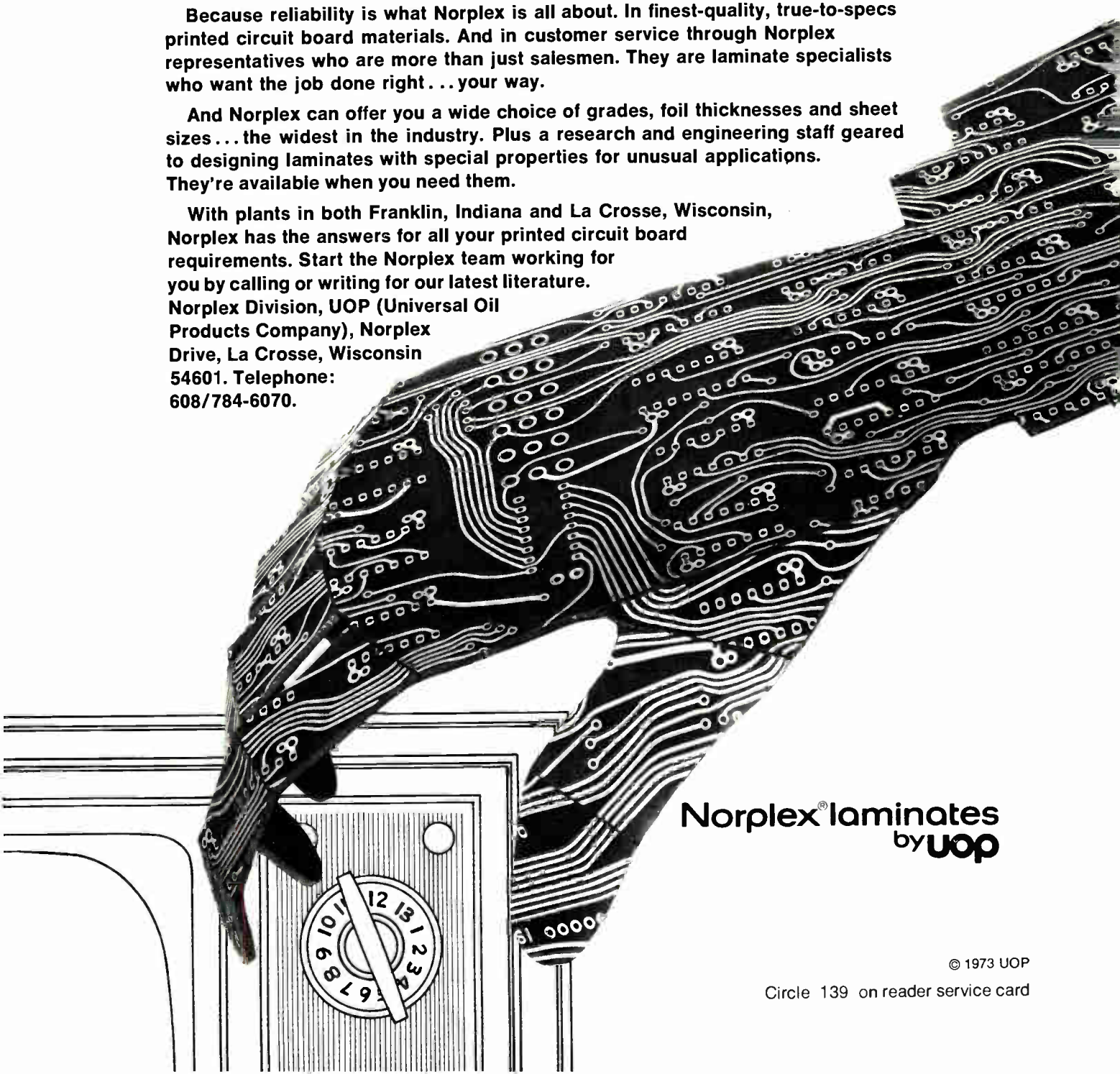
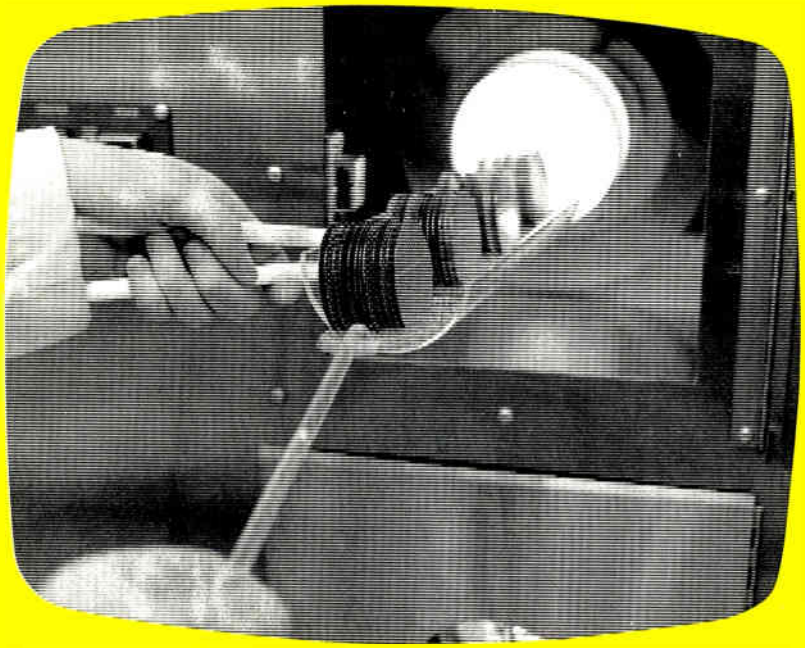


Norplex® laminates by UOP

Circle 139 on reader service card

Watch us go on N-channel!



EA fires up new RAM production facility.

Electronic Arrays just invested $1,000,000 to boost production of N-channel MOS memories. A newly-built production facility devoted exclusively to N-channel RAMs came on-line in May.

That means you'll soon be able to get ample supplies of the fastest, easiest-to-use 1024-bit MOS RAMs on the market.

Like EA1500, which has guaranteed access time of 85 nanoseconds (0° to 70° C), automatic refresh and low power dissipation—typically 160 mW in action, 11 mW on standby.

And EA1501, which combines 150 nsec maximum access with a very low 65 mW typical power dissipation.

Or EA1502, the bipolar-compatible MOS RAM that accepts standard TTL inputs without external level shifting.

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Electronic Arrays, Incorporated, 501 Ellis Street, Mountain View, Calif. 94040. Phone (415) 964-4321.

electronic arrays EA

Circle 140 on reader service card

Shielded-wire connector saves time

Compression-type device requires only 10 seconds to link pigtail to shield; three sizes can handle diameters ranging from 0.055 to 0.205 inch

by Stephen E. Grossman, Packaging & Production Editor

Shielded wiring including coax has long been a plague to manufacturing engineers because most methods of preparing the braided wire shield for termination take as long as 50 to 90 seconds. But Thomas & Betts has developed a connector that enables a short pigtail to be connected to the shield, and assembly time is only 10 seconds. This connector is unique in that it forms to a predetermined closure holding the pigtail securely in contact with the shield—no soldering is required. Thomas & Betts claims that the installed per-unit cost of the connector, called the Shield-Kon wrap-around, is lower than that of any other crimp-type connector.

To install the Shield-Kon wrap-around connector, any outer covering is removed from the cable end to expose the braid. The braid is trimmed back sufficiently to provide a stripping margin between the inner conductor and the braid. The connector is then placed over the cable, the ground wire is added, as shown in the drawing, and the connector is closed by hand. Final closure to a predetermined diameter is performed by either a hand-held compression tool or a bench-mounted press. These tools provide the rolling action for proper connector formation—once the stroke is begun, the die will not release the connector until the connector is properly closed.

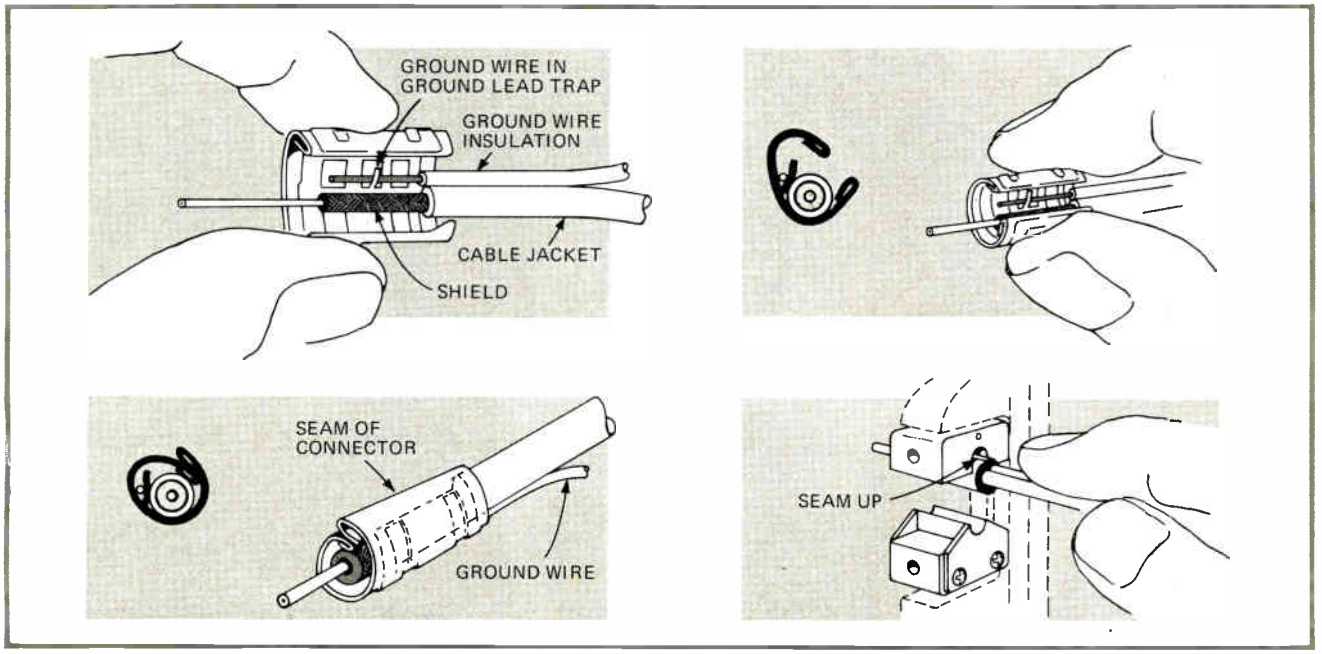
Three connector sizes, in both insulated and uninsulated versions, are being marketed. These handle cables with shield diameters ranging from 0.055 to 0.205 inch. Thomas & Betts says that these three sizes replace the six to 30 sizes that would have to be stocked with other compression-type connectors.

A die set is required for each of the three sizes. As the die closes, it hardens the soft annealed copper body of the connector so the connection becomes permanent—the connector can't be removed from the cable without being destroyed.

The connector's usefulness is not confined to the ends of a cable, for it can be attached anywhere along its span. Since its over-all diameter is small, it offers a space saving of up to 50% over other crimp-type connectors.

There are a number of alternate techniques, but these, besides being time-consuming, can cause damage

In 10 seconds. Ground wire is installed (upper left), connector is hand-compressed (upper right) and then machine-formed (lower right).



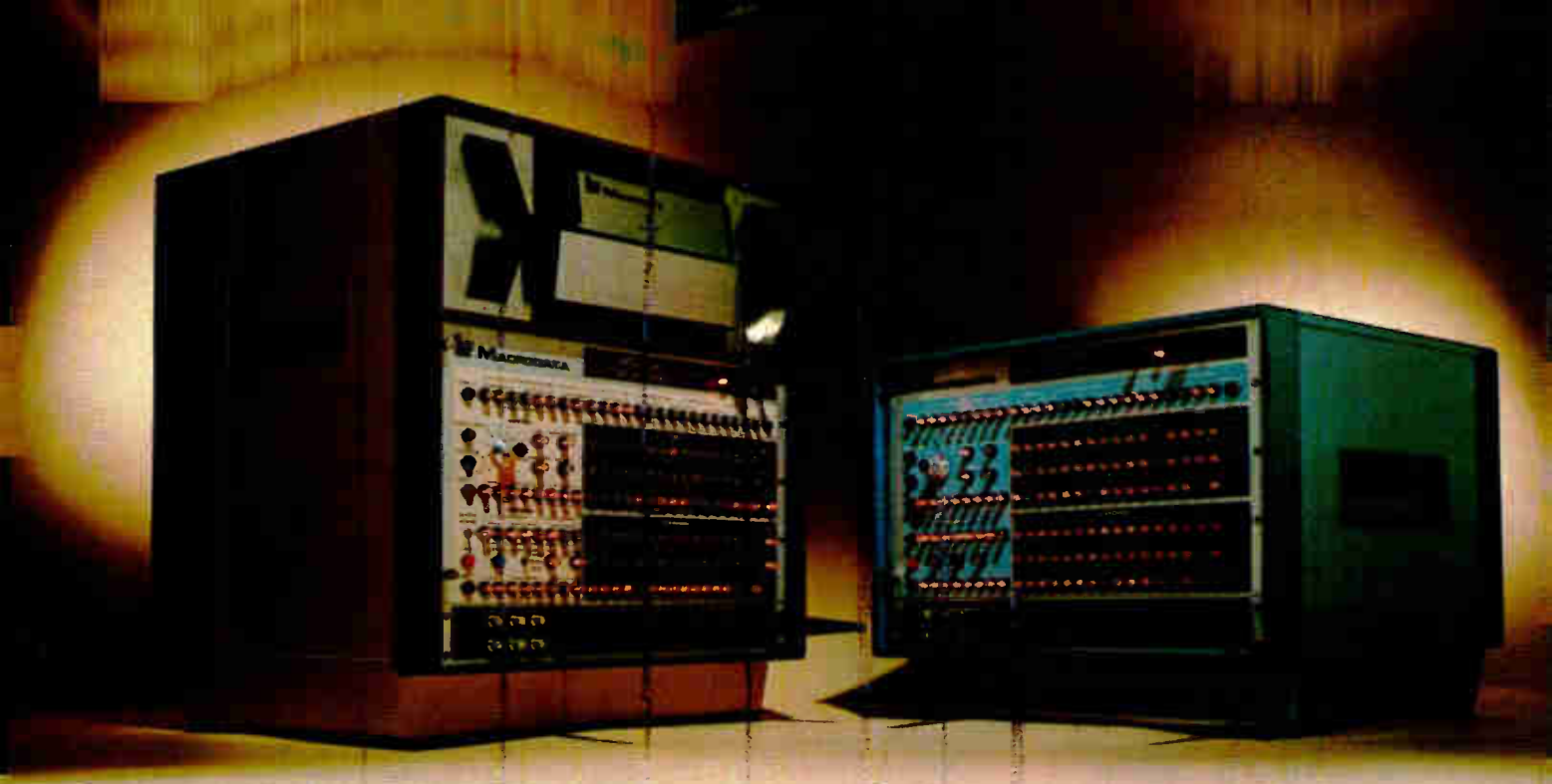
to the shield wires or to the dielectric sheathing of the inner conductor. One of the traditional methods is to comb the weave out of the braid and twist the fine wires to form a lead. Another is to enlarge a hole in the woven shield and push the insulated inner conductor through the shield, which becomes a pigtail that can then be connected. Soldering, which is often employed with these techniques, can cause damage because the heat conducted by the shield can harm low-temperature plastic dielectrics like polyethylene. (A Teflon tube is often inserted between the inner dielectric and the shield, but this adds time and material costs to the assembly process.)

Trial. Electrical, environment and physical tests were performed in accordance with military and commercial standards to assess the performance of the connector. To test tensile strength after a temperature cycle test, the cable was grasped in one set of jaws in a test machine, and the pigtail ground wire connected to the cable by the Shield-Kon was grasped in the other set; the connection was then pulled to destruction at a head travel rate of one inch per minute. The tensile values exceeded 15 pounds for a #22 stranded ground wire and 19 lb for a #20 stranded ground wire. Insulation tests on the insulated version indicated that the breakdown voltage exceeds 500 volts ac.

Vibration tests performed in accordance with MIL-STD-202, method 201, were run on 6-inch cables, with the connector and the shield secured to a vibrating member and the ground wire secured to a stable support. After testing, the samples met the voltage-drop and tensile-strength requirements.

Another test evaluated the impedance variation caused by crimping a connector midway in a 3-foot coaxial cable. Thomas & Betts says that the BNC connector at the cable ends, and irregularities in the cable construction, caused more impedance variation than did the Shield-Kon.

The Thomas & Betts Co., Elizabeth, N.J., 07207 [339]



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Circle 143 on reader service card

Components

Chip resistors save a bond

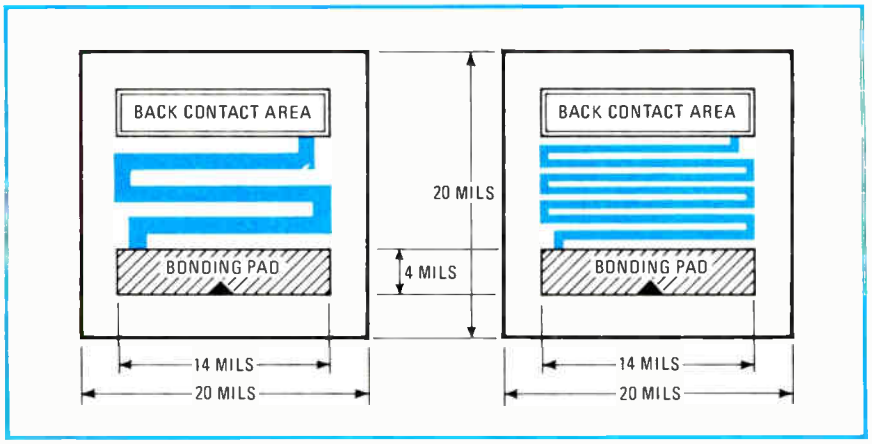
Back contacts on thin-film high-resistance units connect directly to circuit points

On a substrate area that measures only 20 by 20 mils, resistance values as high as 1 megohm are provided by a new family of thin-film chip resistors. The chips are made with tantalum-nitride film, a very stable material that is relatively unaffected by moisture and does not require glass passivation.

Unlike other chip resistors, the series BCR units have a back-contact configuration and require only a single wire bond. (The chip has one large aluminum bonding pad that is notched for easy identification.) The back of the chip is a contact that can be attached directly to the desired circuit point by eutectic bonding or with conductive epoxy. This unique configuration halves the number of wire bonds needed, reducing assembly costs. Initially, the new chips are expected to be used as current-limiting resistors for light-emitting diodes in hybrid circuit assemblies.

Resistance values can range from

Direct connection. Back contact of thin-film chip resistors attaches directly to microcircuit conductor, eliminating one wire bond. Resistance values can be as high as 1 megohm.



100 ohms to 1 megohm, with tolerances of ±5%, ±10%, and ±20%. Temperature coefficients generally range between −150 and −250 ppm/°C, and noise levels are held down by more than 20 decibels. Typically, power rating is 250 milliwatts, and operating voltage is 100 volts. When exposed to a temperature of 125°C for 5,000 hours, and with rated power applied, the chips exhibit a resistance change of less than 0.25% in value.

The resistor element is passivated with tantalum oxide, which is said to be more durable than the glass normally used to passivate other film resistors. The oxide does not contaminate the aluminum pad so that bonding is not affected by the passivation process, as often happens with glass-passivated chips. Furthermore, the chip substrate, which has a nominal height of 8 mils, is silicon, an excellent heat conductor.

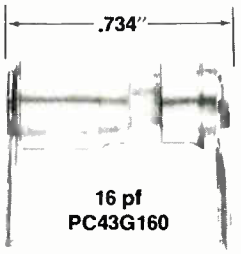
The figure on page 144 shows two typical chip faces—with the tantalum-nitride resistor element (in color), the back contact, and the notched bonding pad. The chips are available now at a 100-unit cost of 28¢ for ±20% tolerances, 35¢ for ±10% tolerances, and 53¢ for ±20% tolerances.

Another series of tantalum-nitride chip resistors is also being introduced at this time. It is a family of terminating networks containing up to 16 individual resistor elements. The resistors are tightly positioned on a heat-equalizing silicon substrate measuring 50 by 60 mils. They provide tracking as good as 1 ppm and can operate at temperatures as high as 150°C. Resistance values range from 50 to 2,200 ohms and are available with resistance tolerances from ±1% to ±10%.

Semi-Films Technology Corp., Subsidiary of National Micronetics Inc., Box 188, West Hurley, N.Y. 12491 [341]

Trimmer capacitors are rated from 5.5 to 40 pF

Available in top- or side-tuned versions with glass dielectric, a range of printed-circuit trimmer capacitors



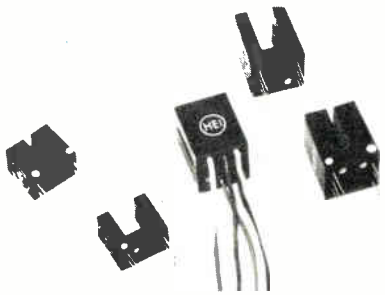
16 pf
PC43G160

20 pf
Voltronics SP20

provides values from 5.5 to 40 picofarads. The SF and SP series have nonrotating piston construction to provide the advantages of linear tuning, no capacitance reversals, high Q, low constant inductance, and high self-resonant frequencies. Price is $3.53 in 1,000 lots.
Voltronics Corp., West St., East Hanover, N.J. 07936 [343]

Integral optical switches drive TTL or DTL circuits

A family of optical switches uses light-emitting-diode photosensors in a single package with Schmitt trigger circuitry. The OS series of devices also features good reliability and high-speed operation, and the units measure less than 0.5 cubic inch. The units can directly drive TTL or DTL circuits with a typical square-wave rise time of 50 ns. They



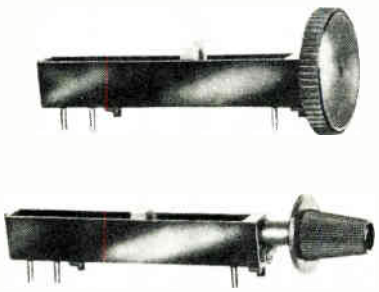
convert low-cycle action to logic switching with no oscillation. Prices begin at $4.80 for lots of 1,000.
HEI Inc., Jonathan Industrial Center, Chaska, Minn. 55318 [344]

Reed relays incorporate a saturable core

A family of multipole magnetic latching reed relays incorporates a saturable-core principle for maintaining contact closure after coil power has been removed. Contacts are opened and closed by means of orthogonal latching, in which the magnetic field normally associated with a reed switch is rotated. A wide operating tolerance results from this method, according to company engineers. Delivery is from stock.
Information Transfer Inc., Box 357, Holcomb, N.Y. 14469 [345]

Variable resistors are for television applications

Designed for use in varactor-diode tuning applications for TV-receiver manufacturers, small rectilinear multiturn composition variable resistors are designated the 120 series. Twenty-five turns of the knob produce one full transversal of the contactor across the carbonaceous resistor element, a construction that is said to provide maximum versatil-



ity. Several knob configurations are available, and price is under 27 cents in production quantities.
CTS of Asheville, Inc., Mills Gap Rd., Skyland, N.C. 28776 [346]

Incandescent lamps operate at high ambient temperatures

Six quartz tungsten-halogen-type incandescent lamps operate at high ambient temperatures—650°C on the bulb—and therefore do not have to be cooled while in use. The quartz bulb eliminates breakage due to thermal shock and improves transmission characteristics. Ratings of 6 to 24 volts, 10 to 200 watts, are offered. There are four filament configurations—rectangular and square oval, horizontal and vertical helix.
Lamps Inc., 19220 S. Normandie Ave., Torrance, Calif. 90502 [347]

Switches offer momentary, maintained contact

A family of miniaturized joy-stick toggle switches offers both momentary and maintained contact, and combinations of the two. Available in a line of XY-axis switches, with the origin of the axes the off position, the switches are available in nine-position, single-pole or five-position, double-pole configuration. They are housed in packages 1.05 inches wide and 1.22 in. long.
Machine Components Corp., 53 Werman Ct., Plainview, N.Y. 11803 [348]

Thermistor probe delivers fast time response

A glass thermistor probe with a fast time response and with a length of a little over ¼ inch consists of a miniature thermistor bead sealed in the tip of a shock-resistant, thin-walled glass tube, with corrosion-resistant platinum-iridium leads. Time constant is of the order of 25 milliseconds in moving water, making the unit particularly suitable for dynamic temperature measurements in liquids and gases. Nominal available resistance is 500 ohms to 300,000 ohms.
Fenwal Electronics, 63 Fountain St., Framingham, Mass. 01701 [349]

1024 and 2048 bit MOS RAMs Multi-Sourced Industry Standards

From the guys who brought you Custom MOS/LSI.
You remember Nortec. We were one of the first high technology houses to supply custom MOS products.

A pleasant surprise.
Now, you can get standard MOS RAMs from Nortec. We've shipped over a million 6002s to satisfied customers (250K/mo.). And that's performance where it counts.

Check us out.

Nortec #	Access Time	Cycle Time	Power Diss.	Size
6002	150ns	250ns	180μW	1024 bit
1103	300ns	580ns	270μW	1024 bit
6003	360ns	595ns	180μW	2048 bit

We have RAMs in volume, ready for delivery, and at prices you'll like. Call and see. It's a better way to do business with the guys who brought you Custom MOS/LSI. Nortec Electronics Corporation, 3697 Tahoe Way, Santa Clara, Calif. 95051.

NORTEC (408) 732-2204

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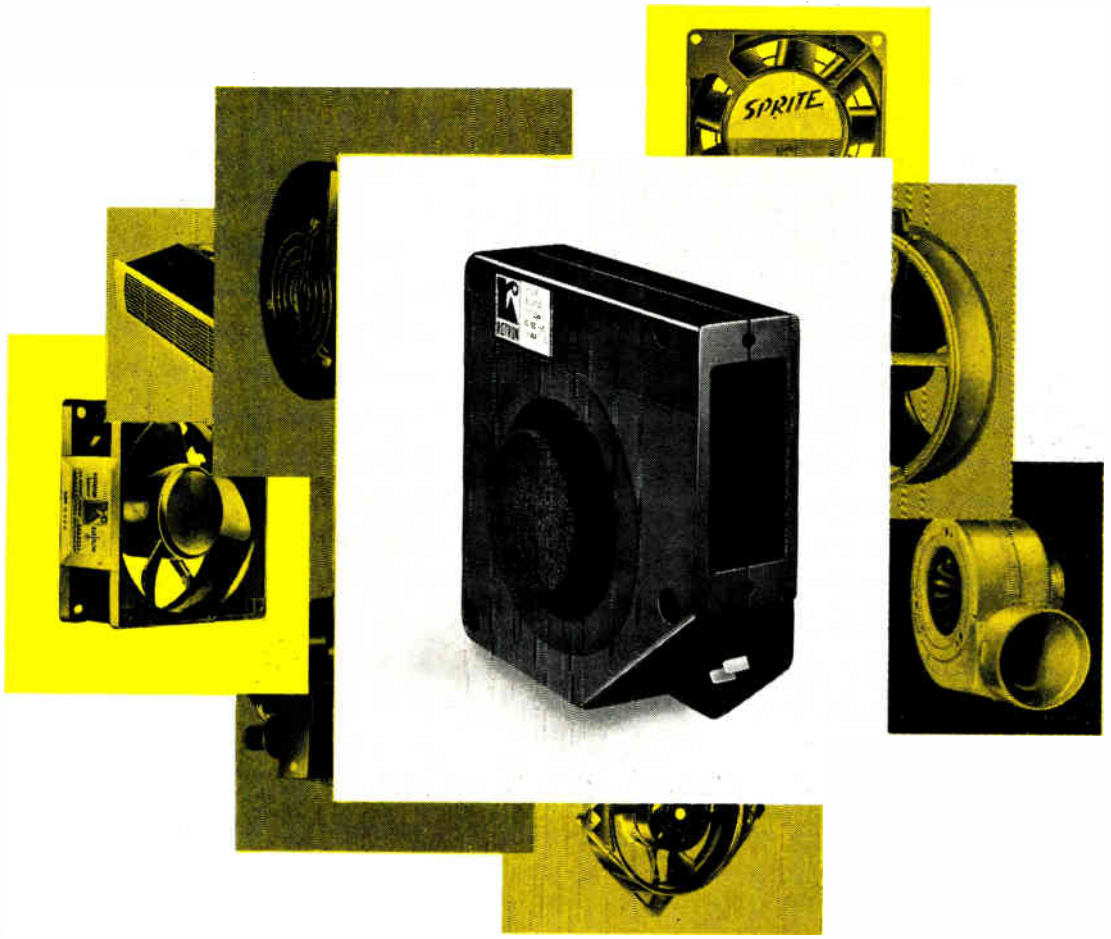

Rotron® has the answer.

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Built around the proven features of the multi-million-installation Muffin® fan, the Biscuit is ideal where cooling air must be forced through tight passages or directed at high velocity over a hot component. It's impervious to moisture or dust, and will run reliably, quietly, and continuously for years without maintenance of any kind. It delivers up to 25 cfm for rack mounted instruments, projector lamps, power supplies, heat exchangers and sinks, core memories, computer terminals, and many office equipment applications.

Whatever your cooling or air moving need, next time you have one, take it to Rotron. As the world's leading manufacturer of precision air moving devices, Rotron has the answer to just about any problem you can pose. And at competitive prices that may surprise you. Ask and see. For more information right now, send for Biscuit Catalog Sheet H-3360.

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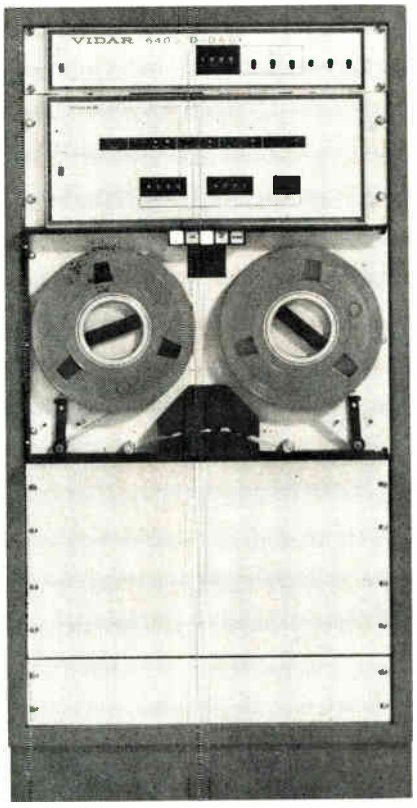

Now VIDAR makes the difference in cost **worth it.**

400 to 20,000 Channel/Second Self-contained Data Logger with AUTORANGE

Hook-up transducers and power-up the new self-contained VIDAR 6403 High Speed, Low-Level Data Logger; you'll get 400 to 20,000 channels/second of extremely accurate data recorded on magnetic tape as low as $73/channel! Included is VIDAR's unique AUTORANGE feature which provides automatic switching of gain ranges as varying input levels are sampled; it's accomplished by internal system logic — no computer is necessary!

The data logger requires no customer interface or software and is easy to operate. The heart of the system is the VIDAR 600 MUX/ADC — A 20,000 channel/second multiplexer and 12-bit ADC with 25 microsecond conversion time, plus two or three-pole filtering per channel which results in excellent noise rejection. Ten full scale ranges varying from eight volts to 15 millivolts may be operator-selected or may be designated by AUTORANGE.

Other VIDAR 6403 system features include selection of first and last channels to be recorded, and single or continuous scanning. LED visual display provides the operator with a base to derive octal or binary data from last channel read.

Computer front-ends The VIDAR 600 MUX/ADC, core of the VIDAR 6403 Data Logger, can function as a computer front-end. It can digitize up to 1024 inputs at 20,000 channels/second, or at 12,000 channels/second with AUTORANGE. Output can be in a serial or parallel binary stream making interfacing to any computer an uncomplicated procedure.

Investigate how the VIDAR 6403, Low-Level Data Logger and VIDAR 600 MUX/ADC can economize and improve the performance of your high speed data acquisition and how VIDAR's vast systems capability relates to total data handling for you.

VIDAR, 265 N. Whisman Rd., Mountain View, CA 94040. (415) 965-3050. In Europe: VIDAR GmbH Kronbergerstrasse 5, Bad Soden/Taunus, West Germany, phone 2 17 65.

Representatives in: Athens 423-471-5 • Brussels 41-81-30 • Essen 70-49-89 • Madrid 215-35-43 • Mexico D.F. 536-09-10 • Milan 4996 • Oslo 23-25-80 • Paris 626-02-35 • Stockholm 64-18-00 • Sydney 43-3333 • Tel Aviv 53459 • The Hague 99-47-40 • Tokyo 669-4121 • Toronto 678-1500 • Vienna 57-25-54 • Zurich 62-82-82.

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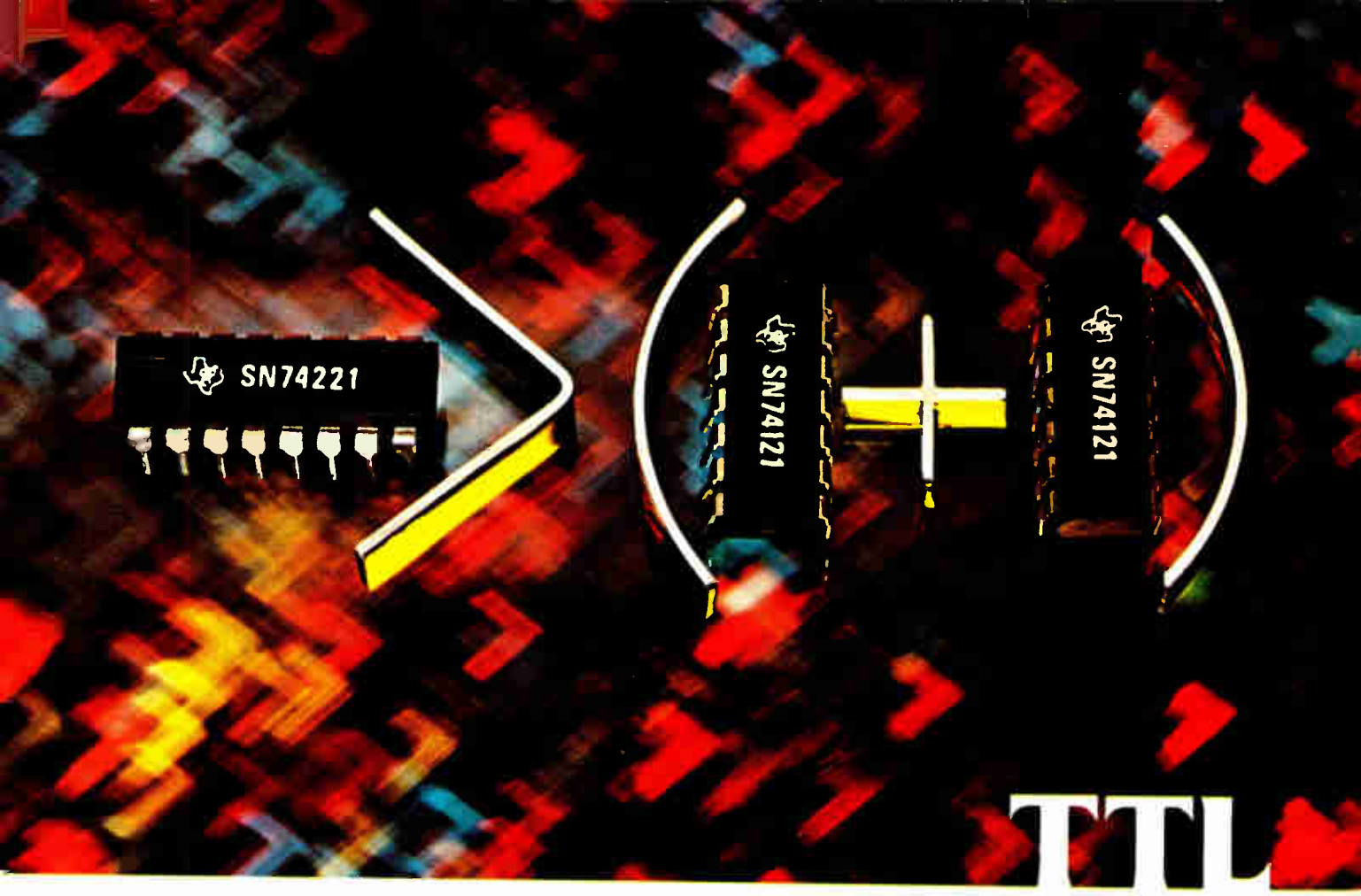


Greater stability in a dual one-shot.

TI's new 54/74221 puts two 54/74121's in a single package.

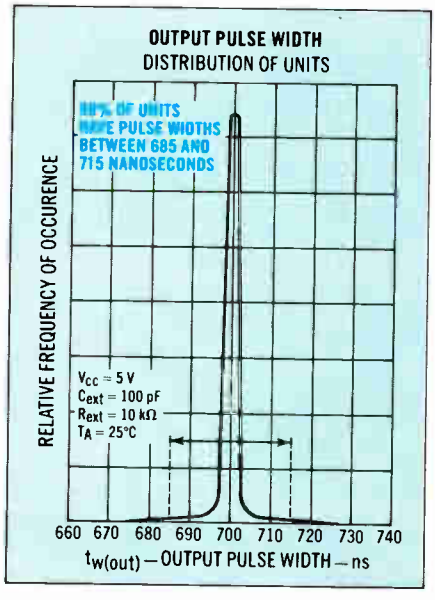
Few IC functions are as popular as the 54/74121. The industry's standard for high stability one-shots.

Now there's a new device that combines the high stability of the 54/74121 single one-shot with the pin-out of the 54/74123 dual one-shot—and outperforms them both. The 54/74221.

It's brand new. It's available in quantity. And it's from TI.

The 54/74221 features an output pulse programmable from 40 nanoseconds to 28 seconds. You can trigger it from either positive or negative going input transitions with complementary outputs available from each one-shot.

The 54/74221 has stable, jitter-free operation even in high noise environments, thanks to the Schmitt-trigger input.



Plus. The 54/74221 has direct overriding clears to terminate output pulses upon command.

If you've been attracted to the performance of the single 54/74121, but disappointed by existing dual one-shots, then the 54/74221 may be just what you're looking for.

Order SN54/74221 from your local authorized TI distributor or directly from TI. For data sheets, specify by type number and write: Texas Instruments Incorporated, P. O. Box 5012, M/S 308, Dallas, Texas 75222.

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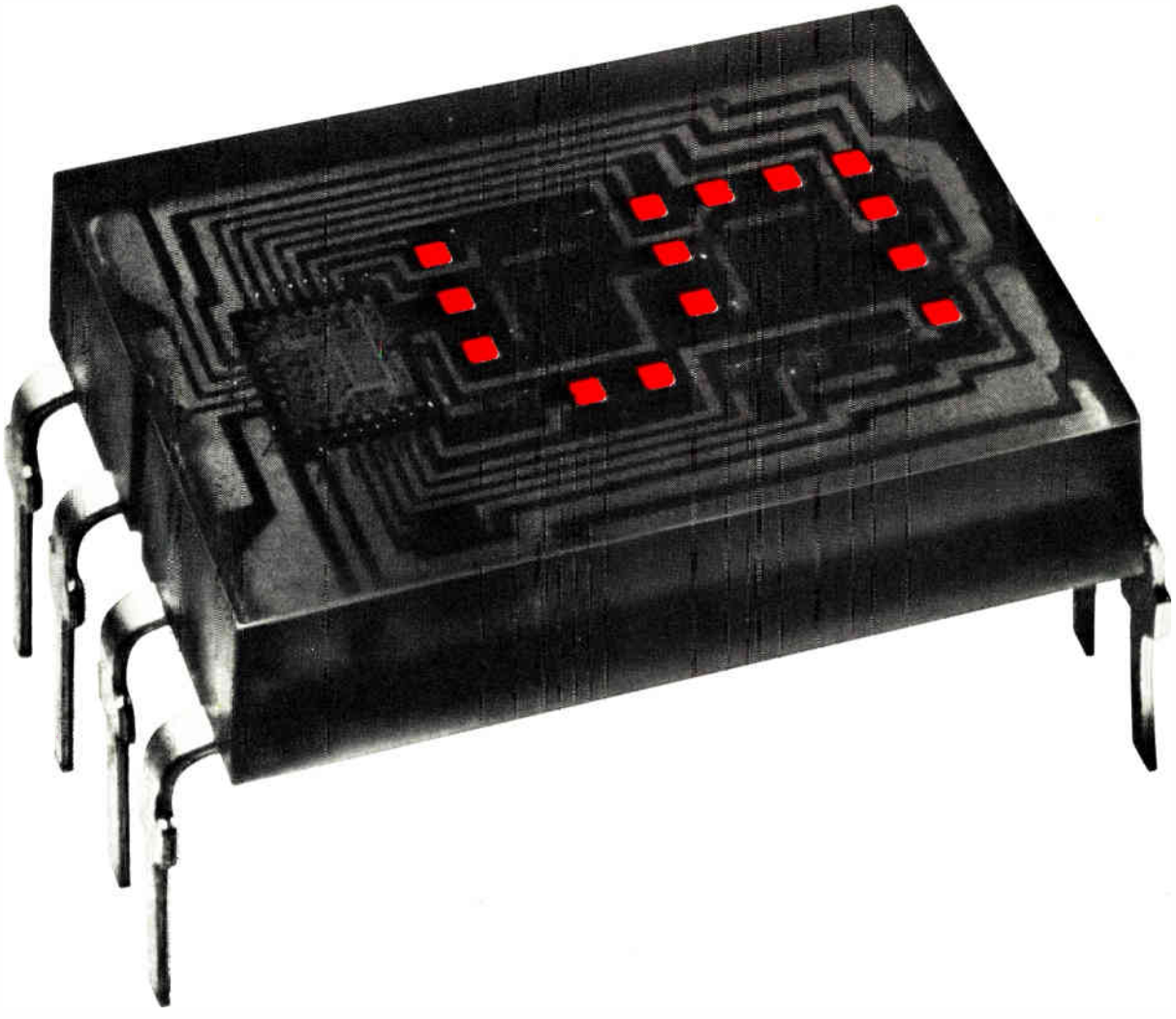

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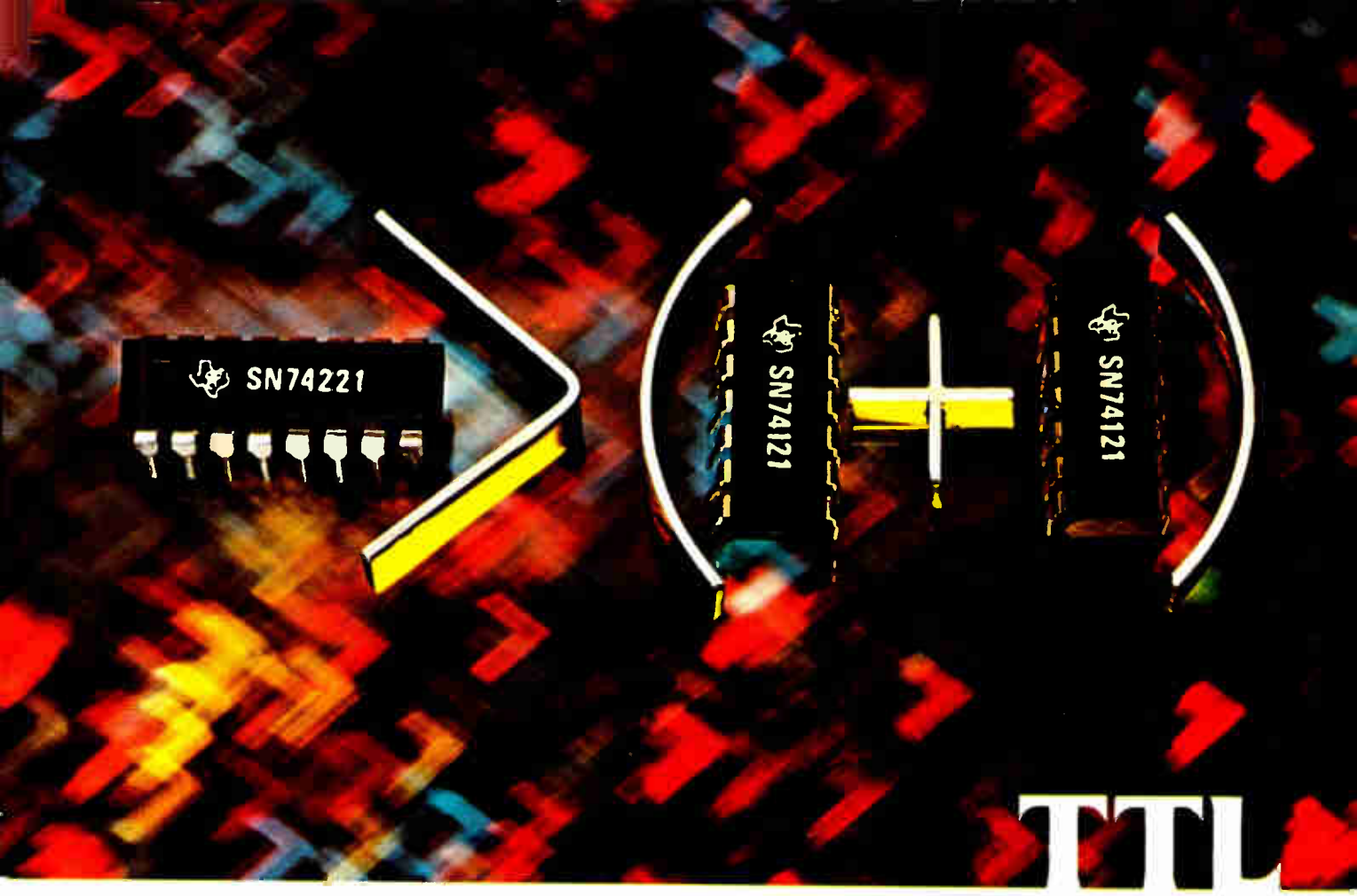

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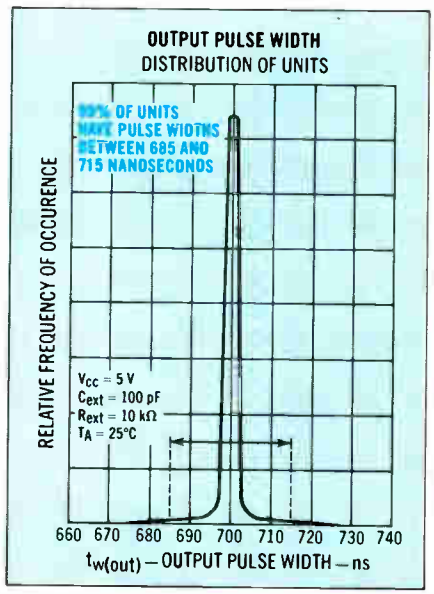

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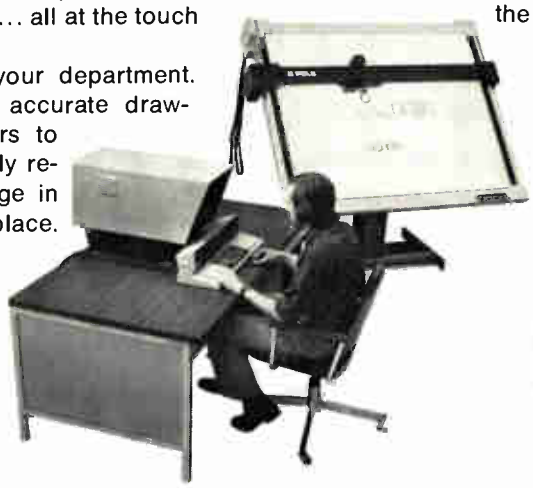

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The Gerber Scientific Instrument Company, Hartford, Connecticut 06101. (203) 644-1551.

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Wickless pipe transports heat

Novel structure reduces thermal resistance to as low as 0.01°C per watt

Although conduction of heat from semiconductor devices is an important use of heat pipes, it is by no means the only one. As developed by Noren Products Inc., heat pipes also serve functions similar to diodes, switches, limiters, and constant-current sources, in thermal management circuits with functions analagous to electronic circuits—though some are still just conductors, able to transport heat from semiconductor devices dissipating up to 10 kilowatts. Most of the pipes originated as custom components of thermal circuits that, for instance, stabilize crystal oscillator temperatures, permit avionics equipment to warm up quickly to operating temperature before cooling begins, or take the place of cooling fans in microwave relay equipment.

The specialized functions and extremely high conduction rates of the Noren designs stem from a construction recently invented by Don W. Noren, president of the firm. Most heat pipes are sealed tubes containing a liquid and a wick.

Noren's newest pipes, dubbed Quikwatts, use proprietary fluids and vapor-support materials rather than wicks. The thermal resistance is low—only 0.01° to 0.03°C per watt—compared with a range of 0.05° to 0.35°C/watt for the wick-type pipes and with many degrees per watt for conventional conductive-cooling devices.

In addition, the tubular construction required by the wick technique is no longer necessary. The wickless pipes come in many sizes and shapes, from miniature 42-mil-thick stripes, suitable for cooling integrated circuits, to hollow cylinders up to 6 inches in diameter and 21 feet long, used for cooling large power supplies and banks of silicon controlled rectifiers.

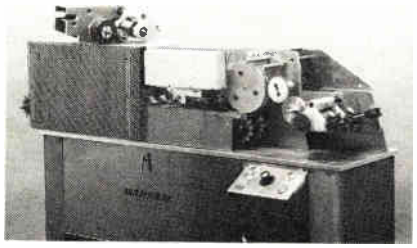
Depending on their construction and materials, the pipes act as isothermal cooling strips, one-way heat conductors (diodes), conductors that switch on when the hot end reaches a threshold temperature, pipes that keep one end at a maximum temperature regardless of how hot the other end gets, and limiters that carry heat at a given rate.

Prices range from 25 cents for the smallest pipes in large quantity up to around $1,000.

Noren Products, Inc., 846 Blandford Blvd., Redwood City, Calif. 94062 G391]

Component markers have fast curing process

A family of infrared axial-lead-component printers has a 6-second curing process. Designated models U-1220 through U-1223, the four machines allow immediate shipping after printing as compared with the



two-hour curing processes required by other methods. The units print at a rate of 20,000 components per hour, using conventional inks. They can handle components up to 4 inches long (including leads) with ±0.0312 inch variation, and components up to 1 inch long with a variation of ±0.015 inch.

Markem Corp., 150 Congress St., Keene, N.H. 13431 [393]

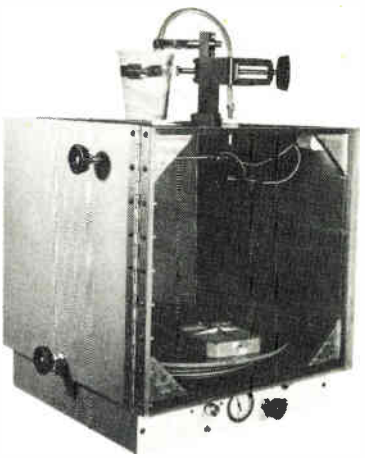
Fusion-welder handles miniature nibbed posts

The model 2000F fusion-welder can handle the welding of miniature nibbed posts, miniature studs, fasteners, and small mechanical assemblies. The machine uses a capacitive discharge operation, which insures repeatablity without residual heat effects for all similar or dissimilar weldable metals. Actual weld time is several millionths of a second.

Electron Fusion Devices, 977 Waterman Ave., East Providence, R.I. 02914 [394]

Encapsulator removes air and moisture from epoxies

Designated the model VE-16 Envax, a vacuum encapsulator removes entrapped air and moisture in epoxies and similar materials during encapsulating, potting, or impregnating processes. The complete operation is done within the chamber; the epoxy is heated automatically as it passes onto the metal plate; air is removed, and the epoxy flows from the metal plate into the air-evacuated mold or component. Price is



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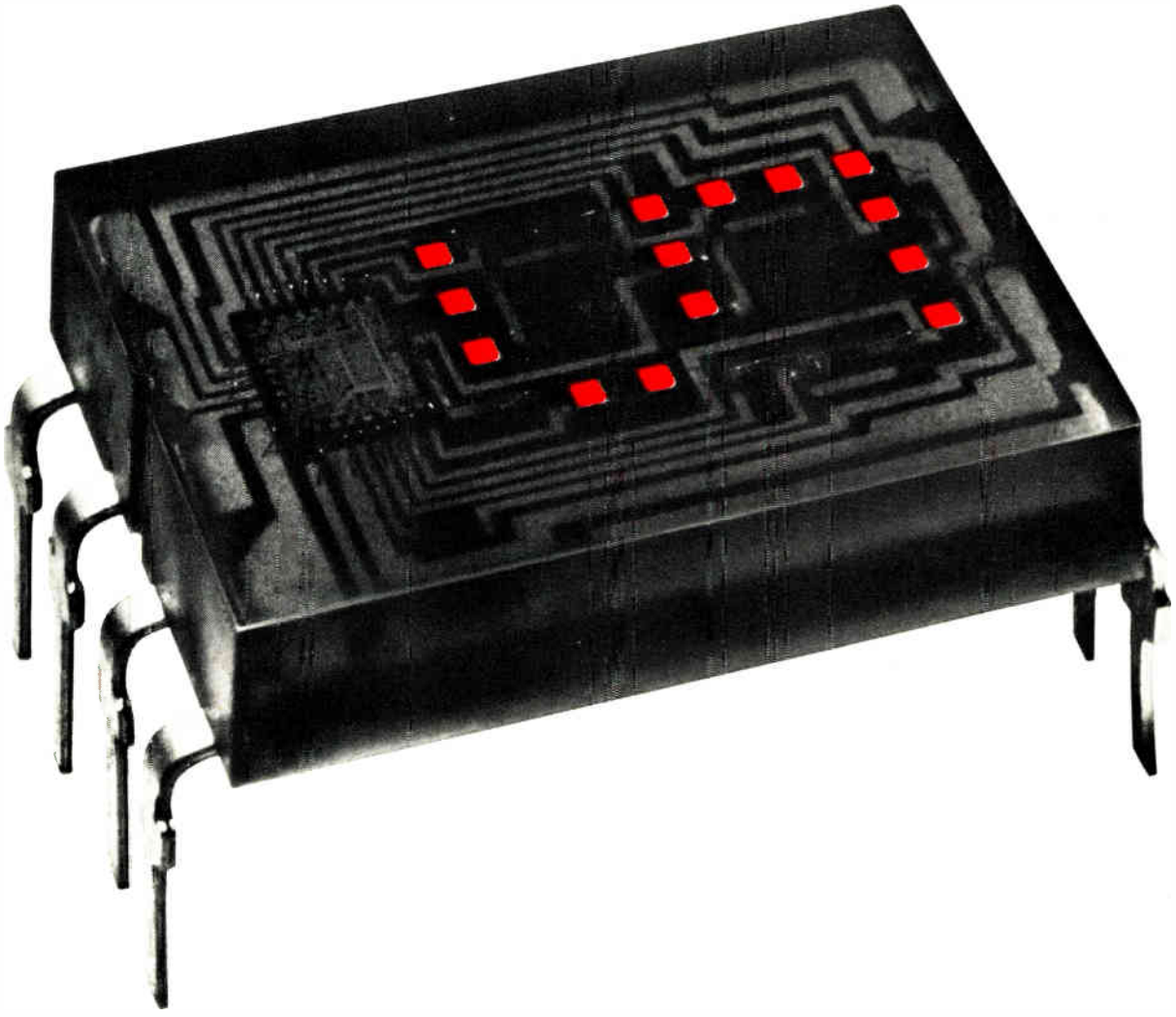

We built in the decoder/driver so you don't have to.

Not only the decoder/driver, but the memory too! It's all in the HP 5082-7300 series solid state display. Available *now*. In quantities to meet your production needs.

It's completely TTL compatible. All you do is address it directly with four-line BCD input. The on-board IC allows for either the storage of input data or real-time display. You save design time, space and money, and get a completely reliable integrated display system.

A bright 0.290 inch high, shaped character gives excellent readability over a wide viewing angle in a compact 0.600 inch by 0.400 inch package. And best of all, the price is only $8.25* in 1K quantities. If you need a larger character write for information on our 1.5" 5082-7500 solid state display. It's also TTL compatible and has the decoder/driver built in. For immediate delivery on the HP 5082-7300 or 5082-7500 call your nearby HP distributor today.

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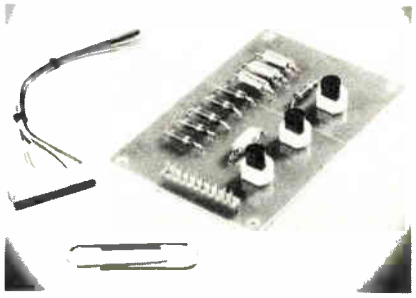
Mikon Products, Box 369, Seymour, Conn. 06483 [396]

Circuit-board connectors require little space

A line of miniature printed-circuit-board connectors is designed specifically for applications where there is limited space. The connectors pro-



vide the means to construct a small instrument having a removable p-c board, rather than a captive one. The line consists of 10 and 20 feed-through contacts spaced 0.075 inch apart in phenolic strips for wave-soldering. Price is $2.25.
Microtech Inc., 777 Henderson Blvd., Folcroft, Pa. 19032 [395]

Marking inks for components reflect and emit light

A marking method for the inspection of electronic components offers two kinds of ink—removable and permanent—available in five fluorescent colors that reflect and emit light. The removable ink is nondestructive and nonconductive and contains no silicones. The permanent inks are waterproof and flex-

ible when dry. Both types adhere to any surface. Price of one marker is $2.95, and a set of five pens is $13.25.
Metron Optics, Box 690, Solana Beach, Calif. 92075 [397]

Beam-lead bonder provides interchangeable assemblies

A beam-lead bonder is adaptable to almost all package styles involving thermocompression bonding of semiconductor or complex hybrid units in any system. Three options in head assemblies are available and include a self-compensation hard tip, a stationary hard tip, and a compliant single tip. Also interchangeable are shuttle assemblies,

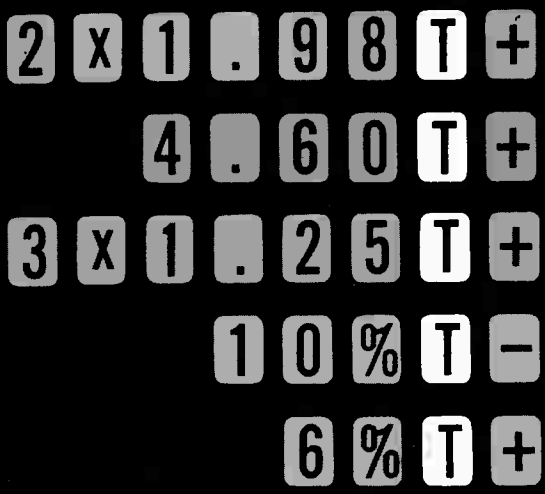
substrate and die positioners, substrate tables, and dice dish assemblies.
J. & A. Keller Machine Co. Inc., Electronics Division, 2320 Military Rd., Buffalo, N.Y. 14150 [398]

Modular memory tester features pattern generator

A memory tester, called the Ranger 1, is the first of a line of test systems and is the core of the family, which can be upgraded modularly. The Ranger 1 features a 20-megahertz hardware-oriented pattern generator, and is a dedicated functional pattern exerciser designed for incoming inspection and wafer testing. Price starts at $15,000.
Fairchild Camera & Instrument Corp., 2500 Deer Creek Rd., Palo Alto, Calif. 94304 [399]

T-totaler.

FIVE FUNCTION CALCULATOR ARRAY WITH MEMORY PROGRAMMED FOR AUTOMATIC ACCUMULATION—ACCEPTS ENTRIES ITEM BY ITEM, PRICE BY PRICE, PROVIDES FOR TAXES, DISCOUNTS, MARK-UPS



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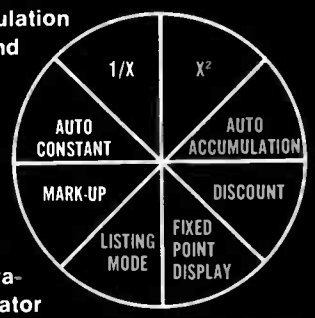
• Separate memory may be used either as a storage location for initial constants and intermediate results *OR* as an accumulator to total the results of a series of individual problems. • Automatic accumulation • Normal chain calculation • Calculation with memory • Discount and allowance calculation • Automatic constant operation • Squaring and reciprocal operations • Selectable fixed or floating decimal point (entry and display) • Internal memory (single key operation) • Internal clock generator • Direct LED segment drive • Auto-clear • Low battery detector • Display blanking • Supplied in a 28-lead DIP.



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Semiconductors

Automotive ICs go to market

Chips built for tachometer, car controls offered for industrial, consumer jobs

Can custom-designed automobile electronic circuits make the grade as standard products? The Fairchild Components group has high hopes for a monolithic tachometer subsystem, initially developed as an adaptive-braking subsystem for antiskid controls, and a companion triple operational amplifier to control fuel-metering on fuel-injection systems of automobiles.

The company says these are the first automobile circuits to be marketed as general-purpose consumer and industrial electronic components.

They were developed in Fairchild's Analog Products division and will be sold through the Components Group in the Consumer Microcircuits department.

The μA7350 tachometer converts the alternating-current input from a revolutions-per-minute sensor to a pulse-width-modulated square wave at twice the input frequency. On the same chip are terminals for a low-pass RC filter, together with an operational amplifier and two comparators. The latter are used to integrate the square wave, buffer the resulting analog signal, and generate overspeed and underspeed error-control signals in automobile systems.

But the chip is also a versatile frequency-to-voltage converter, points out Howard Murphy, custom products manager, whose staff designed the circuits. The IC can indicate signal frequencies on an analog voltmeter, stabilize the speed of a dc motor in a battery-powered tape recorder, drive a color organ (a display of colored lights that fluctuate in harmony with music signals), or generate analog control signals from keyed telephone signaling tones, for example. The telephone key panel can provide a handy method of controlling remote machinery, Murphy says.

The μA7351 chip has three independent operational amplifiers with input stages similar to the 741. The outputs, like those on the μA7350, have uncommitted collectors so that the outputs can be operated at any load voltage up to 24 V. The output design also allows the outputs of the two chips to be wire-ORed. When used in the automobile systems, the op amps on the μA7351 are generally connected to the output of the op amp on the μA7350 to increase the number of control signals generated by the tachometer subsystem. But the μA7351 is useful for any multiple amplifier, buffer, or comparator functions, according to Murphy.

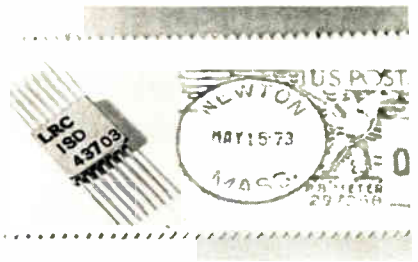
Both circuits operate on single power supplies to 24 V and meet auto-industry environmental specifications, including an operating temperature range of −40°C to 85°C. Maximum output currents are 5 milliamperes, except for the tachometer's square-wave output, rated at 50 mA.

Unit prices in hermetically sealed dual in-line packages are $4.88 for the μA7350 and $4.20 for the μA7351. In 100 to 999 lots, the prices are $3.25 and $2.80, respectively.

Fairchild Semiconductor Components Group, Fairchild Camera and Instrument Corp., 464 Ellis St., Mountain View, Calif. 94040 [411]

Switches, driver housed in single flatpack

A flatpack device measuring ⅜ inch contains four switches and drivers. Designed for rf control in the 10-to-1,000-MHz range, the ISD-43700 series has TTL-compatible driver inputs, and features a built-in fail-safe provision. With the input gate level open-circuited, the switch goes to an isolation state. No bias connections or dc blocks are required in the rf line. There are three models in the



series, each having a switching speed of 5 microseconds maximum.

LRC Inc., 11 Hazelwood Rd., Hudson, N.H. 03051 [413]

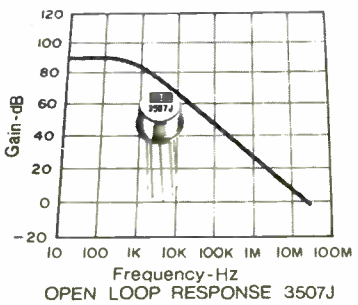
Low-noise FETs operate from 500 MHz to 1 GHz

Four silicon insulated-gate field-effect transistors are for use in television receivers, communications equipment, and amplifiers operating in the high uhf, low-microwave-frequency region from 500 MHz to 1 GHz. Both D-MOS (double-diffused MOS) models are ion-implanted. Gain is 10 dB typical at 1 gigahertz with noise levels of 4.5 dB typical at 1 GHz. Price of single-gate models SD200 and SD201 is $4 each in 100-lots. The dual-gate SD300 and AD301 models are priced at $3 and $3.25 in the same quantities.

Signetics, 811 E. Arques Ave., Sunnyvale, Calif. 94086

Wideband IC op amp has fast slew rate

For applications in data-acquisition systems and high-speed test equipment, the model 3507J IC operational amplifier features a slew rate of 120 volts per microsecond and a settling time to 0.1% of 200 nano-



OPEN LOOP RESPONSE 3507J

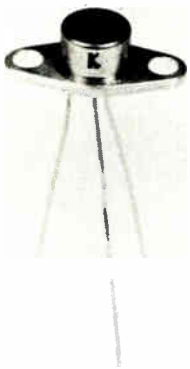
New products

seconds. Gain-bandwidth product is specified at 20 megahertz. The unit is compensated to allow faster slewing and greater bandwidths for gains of three or more. For gains greater than three, gain rolloff is 6 dB per octave. Price is $11 each for 1 to 24 pieces and $7.50 for 100 to 249.

Burr-Brown Research Corp., International Airport Industrial Park, Tucson, Ariz. 85706 [415]

Power transistor can operate as amplifier to 175 MHz

A power transistor with improved thermal characteristics can be used electrically as an amplifier from dc to 175 megahertz. It is priced from 40 cents to 95 cents in 1,000 lots,



and it has a low collector saturation voltage of 1.5 A. The rf capabilities are such that at 13 volts' operation, it is possible to obtain 1.3 watts rf output at 70 MHz with 5 dB gain.

Kertron Inc., 7516 Central Industrial Dr., Riviera Beach, Fla. 33404 [417]

Tuning diodes are aimed at low-frequency a-m

The MD1663 series of tuning diodes have 4-volt capacitance values of up to 2,200 picofarads. They also offer a capacitance tuning ratio of 2.3:1 from 2 to 15 volts, and are suited for low-frequency a-m applications. Other features include an inductance of 1 nanohenry and a Q of

over 100, measured at 20 MHz and 4 volts' bias.

MSI Electronics Inc., 34-32 57th St., Woodside, N.Y. 11377 [418]

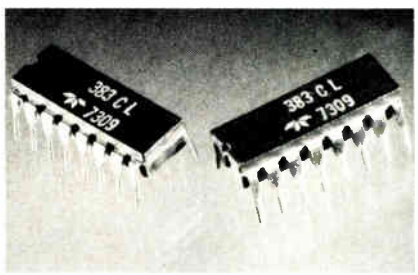
128-bit Isoplanar memory offers fast access times

Designated the model F10405, a 128-bit ECL Isoplanar random-access memory offers a typical access time of 12 nanoseconds and a typical chip-select access time of 3 nanoseconds. Maximum read-write access time is guaranteed at 15 ns over a −5% variation in power-supply voltage and over a 0- to +75°C temperature range. Price is $60 each for 1 to 24 pieces and $48 for 100 to 999.

Fairchild Camera and Instrument Corp., Semiconductor Components, 464 Ellis St., Mountain View, Calif. 94040 [416]

BCD-to-7-segment decoder drives LED displays

A BCD-to-seven-segment decoder is designed for driving LED displays and is part of the HiNIL series. Called the model 383, the unit is compatible with MAN-1 and Data-Lit 10 displays. Each output of the 383 will sink 20 milliamperes, thereby permitting the display to be



driven directly without external components other than current-limiting resistors. Price for 100 to 999 units is $283 or $3.56 each, depending on temperature range and packaging.

Teledyne Semiconductor, 1300 Terra Bella Ave., Mountain View, Calif. 94040 [419]

Over 15,000 delivered in less than a year

Get your edition of the most popular digital multimeter ever made now. Get low cost of ownership, immediate delivery and super reliability.

Value and reliability are two important reasons why the Fluke 8000A has become the most popular digital multimeter ever and the standard of excellence in the low cost field.

For the money, $299, you can't buy a better multimeter. No one gives you higher accuracy (basic dc accuracy is 0.1%), greater sensitivity or more protection. Here's an instrument with 26 ranges to measure ac/dc volts from 100 microvolts to 1200 volts, currents from 100 nanoamperes to 2 amperes and resistance from 100 milliohms to 20 megohms.

Reliability

You can expect your 8000A to work day-in, day-out, year after year. We guarantee 20,000 hours mean-time-before-failure, but with 15,000 units delivered, our own studies indicate a MTBF of 56,000 hours—the equivalent of 15 years. Only Fluke uses both analog and digital LSI circuitry in one instrument. And to top everything off, we put everything in a high impact case with securely mounted internal electronics.

Expanded capability

Wide choice of low cost options including rechargeable battery pack, digital printer output, deluxe test leads, high voltage probe, RF probe, 600 ampere ac current probe, carrying case, dust cover, and rack mount to make your 8000A the most powerful and versatile low-cost multimeter available anywhere.

Stock delivery and local service

You can get your Fluke 8000A from local sources today. Fluke backs the 8000A with service centers conveniently located throughout the United States, Canada, Europe and the Far East for fast 48-hour turnaround repair service.

Order yours today on a 15 day no obligation trial basis. Use your American Express, BankAmericard, Mastercharge, company purchase order or even money.

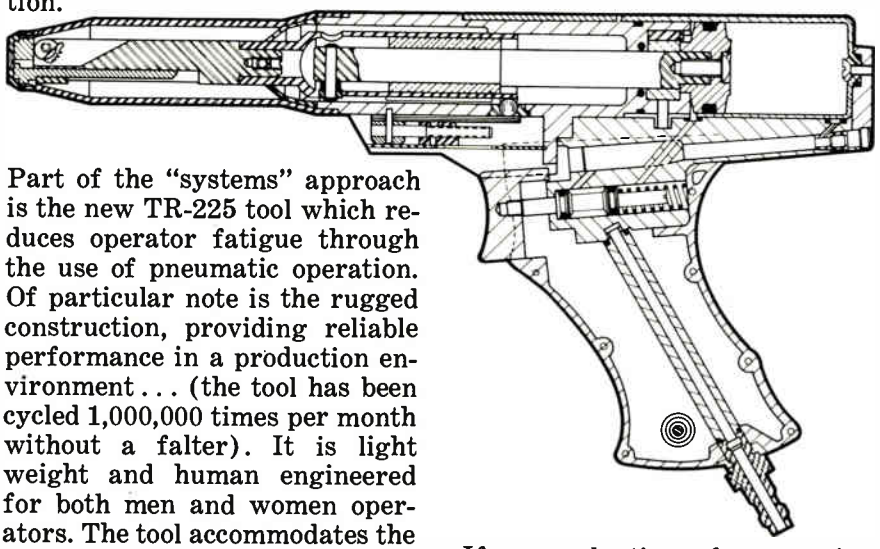
In the continental U.S., dial our toll free number 800-426-0361 for the name and address of your nearest local source. Or contact us directly by addressing, John Fluke Mfg. Co., Inc., P.O. Box 7428, Seattle, Washington 98133. Phone (206) 774-2211. TWX: 910-449-2850. In Europe, address Fluke Nederland (B.V.), P.O. Box 5053, Tilburg, The Netherlands. Phone 013-67-3973. Telex: 844-52237. In the U.K., address Fluke International Corp., Garnett Close, Watford, WD2 4TT. Phone, Watford, 33066. Telex: 934583. In Canada, address ACA, Ltd., 6427 Northam Drive, Mississauga, Ontario. Phone 416-678-1500. TWX: 610-492-2119.

FLUKE®

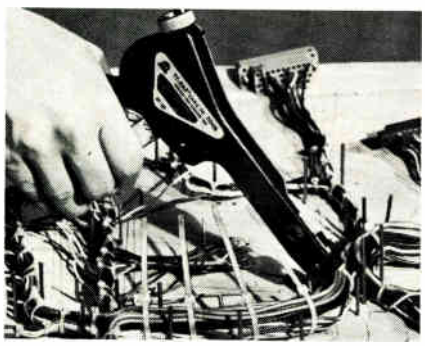
Circle 159 on reader service card

Tooling Technology Offers Systems Approach to Production Wiring

With over 14 years of experience plus the world's largest team of wire tying and harnessing specialists T&B has developed a systems approach to wiring that makes harnessing a cost-controlled proposition.

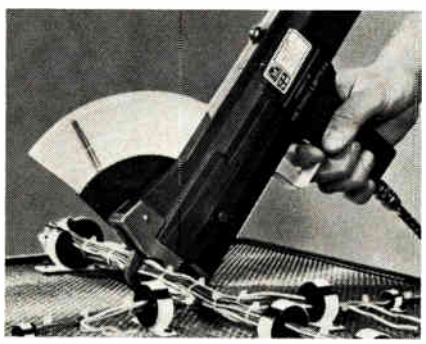


Part of the "systems" approach is the new TR-225 tool which reduces operator fatigue through the use of pneumatic operation. Of particular note is the rugged construction, providing reliable performance in a production environment... (the tool has been cycled 1,000,000 times per month without a falter). It is light weight and human engineered for both men and women operators. The tool accommodates the majority of TY-RAP® tie sizes ...16 in all...with bundle ranges from 1/16" to 4". A further convenience for the operator is that the long narrow nose gets into confined areas easily. If your production volume is such that it does not require the exclusive use of the TR-225 perhaps the new WT-193 hand tool would supplement your operation.



This tool accommodates the same bundle range as the TR-225. With a similar narrow nose and long barrel, it is well suited for close-up work, breakout points and in tough to reach places. This particular design gives the operator the convenience of a long tying stroke with one squeeze of the trigger... the tie is cinched to a preset tension and trimmed flush with the head. The speed of tying is good for smaller volume tying as compared to the pneumatic TR-225.

If an evaluation of your tying requirements reveals a high volume of tying bundles in 1/16" to 5/8" diameter, consideration of our new automatic production tool (TR-300) would be wise.



Used in conjunction with our complete series of harnessing aids (routing clamps, corner posts, breakout springs) wires are routed with few nails to facilitate both fabrication and tying.

With good harness board preparation, the TR-300 can offer 4-5 times quicker installation than hand tying. This tool slides a TY-RAP tie under and around the bundle, cinches it to a preset tension, locks it and trims it flush with the head... all in 8/10 of a second.

Our harnessing specialists will review your tying operation and recommend appropriate tooling.

Another TY-RAP product which facilitates harness fabrication is the new harness board. Set-up costs just about disappear when you adapt this board into your present operation. It is a fully reusable modular board that can be enlarged by snapping the interlocking panels together. Metal screening covers the self-healing polyethylene foam center. Both sides can be used. The harnessing aids are installed easily since standard nails are pushed into the board by hand. Cat. No. HBF-02-03.

One of the most important considerations in using plastic ties is the reliability of the tie's locking device. Only TY-RAP self-locking ties have a patented, non-magnetic, stainless steel, locking wedge embedded in the cable tie head. You get a grip of steel every time with TY-RAP self-locking ties.

The TY-RAP system was developed by T&B to answer all types of production wiring and harness fabricating needs whether large volume or small. Your production rates, system flow and total installed costs are major concerns of ours. In our evaluations of harness fabricating techniques used across the country, operator performance, fatique factors and process convenience appeared as major considerations in the cost structure of harnessing. Our harnessing specialists are equipped to study these costs as well as all pertinent factors involved in your wiring and harnessing operations. Write or call us today.

The Thomas & Betts Co., Elizabeth, New Jersey 07207, (201) 354-4321. In Canada, Thomas & Betts Ltd., P.Q.

529

T&B ENGINEERED THOMAS & BETTS

Division of Thomas & Betts Corporation

New *TY-RAP*® Tool completes one million ties every month

Triggered 70,000 times each day without a misfire!

As you read this message, the production model of this pneumatic hand tool, TR-225, is continuing its life cycle test... 1,000,000 cycles per month without a falter.

This 20 ounce tool ties wire bundles from 1/16″ to 4″ diameter with just about every regular and "Slim Line" type TY-RAP® cable tie . . . 16 sizes in all. It reduces operator fatigue . . . and is particularly well suited for close-up work, break-out points and tying in confined places in equipment.

Our other new production tool, the high speed TR-300, automatically positions a TY-RAP tie around bundle, cinches to a preset tension, locks tie securely and trims evenly . . . all in 8/10 of a second . . . and on bundle diameters ranging from 1/32″ to 5/8″.

Write for new catalog. The Thomas & Betts Co., Elizabeth, New Jersey 07207, (201) 354-4321. In Canada, Thomas & Betts Ltd., P.Q.

Sold Only Through Authorized T&B Distributors

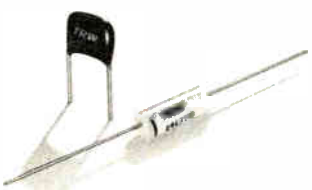
T&B ENGINEERED **THOMAS & BETTS**

Division of Thomas & Betts Corporation

524

Circle 161 on reader service card

think small



. . . *with TRW metallized film capacitors.* For example, metallized polycarbonate ultra-miniatures (Type X463). Real problem solvers in precision circuitry where stability with small size is essential. Capacitances: .001 to 10.0 mfd in 50, 100, 200, 400 VDC. High IR, low DF, fully rated from −55 to +125°C—with less than 1½% capacitance change. Rugged, plastic film case. For similar performance in a metal enclosed unit, ask about Type X482. And for real space savings in a rigid pre-molded case, check the X440.

And then there are X601PE subminiatures in metallized Mylar* construction with dipped epoxy coating. Capacitances: .01 to 10.0 mfd—in 100 and 200 VDC. Temp.: −55 to +100°C (to 125°C with derating). Tough, self-healing. Great for high-density PC's, humid environments, precision applications. (Metallized Mylar units also available tape-wrapped or metal enclosed.)

One other thing. We figure you can't make quality capacitors and me-too capacitors under the same roof. Because sooner or later, one operation will goof the other one up. So we take the quality route. Count on it.

Write for catalog or application engineering assistance. TRW Capacitors, an Electronic Components Division of TRW, Inc. Box 1000, Ogallala, Nebraska 69153. (308) 284-3611.

*Du Pont T.M. for Polyester Film

TRW® CAPACITORS

Subassemblies

Converters break DPM price level

Integrating a-d converters need one 5-V supply, have isolated floating front ends

Since the heart of a digital panel meter is an integrating analog-to-digital converter, why does a packaged converter cost so much more than the DPM built around it? Answer: the much higher volumes in which DPMs are manufactured.

This inverted price structure looks likely to be changed by two integrating a-d converters from Analogic. Called the MP2321 and the MP2322, the converters differ only in that the first unit has a BCD output, and the second a binary output.

Both converters are 2,000-count machines—that is, 3½ digits and 11 bits plus sign, respectively—and sell for $79 in quantities of 100.

Like the so-called logic-powered DPMs, the new converters need only a single 5-volt supply. An internal dc-to-dc converter allows the analog front end of the circuit to be completely isolated from the digital circuitry and its error-producing noise spikes. Furthermore, this isolated, guarded, bipolar input can be floated as much as ±300 volts with respect to system ground, making the converter ideal for handling remote signals which may not be referred to ground.

Both units produce maximum errors of ±(0.05% of reading + 1 count), and have a maximum temperature coefficient of error of 50 ppm/°C Accurate operation is enhanced by circuitry that automatically resets the converter's zero reference at the beginning of each conversion cycle.

The converters should operate well in computer-controlled systems because they include such features as variable conversion rates, the capacity for making ratiometric measurements and executing a conversion cycle on command, and a choice of BCD or binary outputs.

The variable conversion rates (up to 100 conversions per second) and conversion-on-command features make it easy to synchronize the converter with an industrial process that it may be controlling. Its ratiometric mode allows automatic compensation for such potential sources of error as transducer power-supply drift. And the outputs, which are DTL- and TTL-compatible, permit automatic examination of the data by displays and printers.

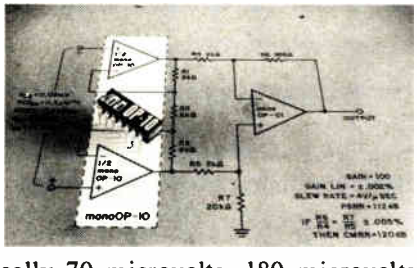
All these features, plus their high common-mode voltage ratings, make the converters ideal for such applications as recording, analytical, and industrial control instrumentation systems, process control instrumentation, and single-current-loop remote indicator systems.

Delivery time is four weeks.

Analogic, Audubon Road, Wakefield, Mass. 01880 [381]

Op amp delivers offset voltage match of 70 μV

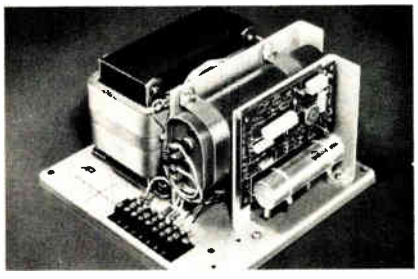
Consisting of two independent, compensated monolithic operational amplifiers housed in a single dual in-line package, the monoOP-10 is designed as an instrumentation op amp. A high degree of matching between channels is said to be provided on all critical parameters, including offset voltage match of typically 70 microvolts, 180 microvolts maximum, and tracking of offset voltage versus temperature of 0.3 μV/°C typical, 0.8 μV/°C maximum. Matching of non-inverting input bias current is typically 0.8 nanoamperes, 2.8 nA maximum. Price ranges from $16 to $90.



Precision Monolithics Inc., 1500 Space Park Dr., Santa Clara, Calif, 95050 [340]

Ac voltage regulator takes any input from 50 to 260 V

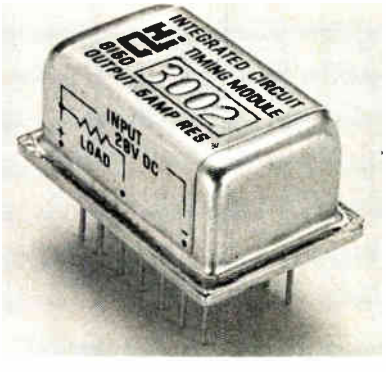
Using the volt-second integral of a magnetic-cored transformer, an ac voltage regulator achieves a constant output voltage independent of the input voltage. Designated the Controfluxer, the unit is 50% smaller and priced about 40% less than conventional regulators. It will take any input from 50 v ac to 260 v ac, anywhere on earth, and provide a rated output of 117 v ac or 234 v ac, regulated to within ±0.2% despite fluctuations in input voltage and frequency. Prices start at $176.

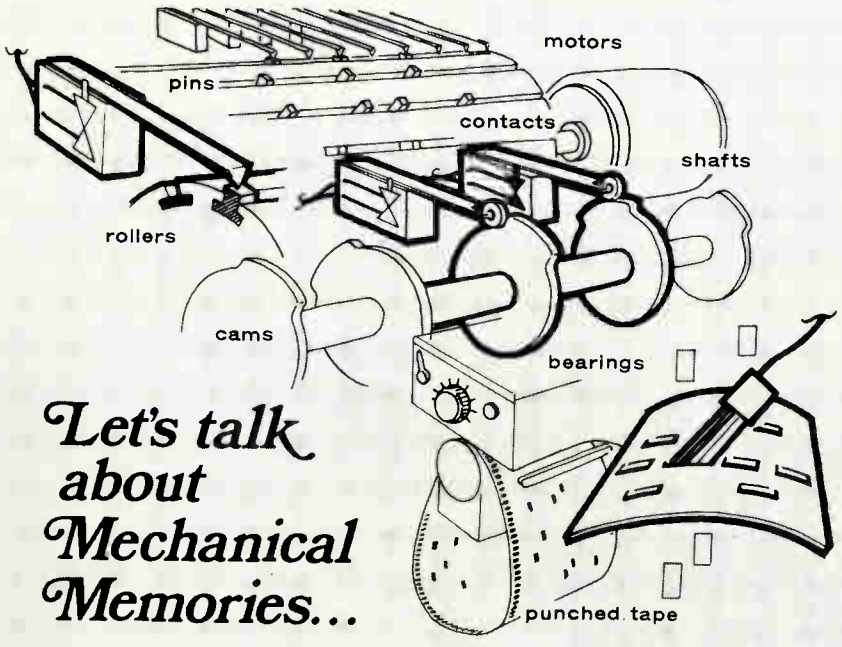


Advanced Power Inc., 1621 South Sinclair St., Anaheim, Calif. 92806 [382]

Timing module provides delay-on-energize

A hybrid thick-film timing module provides delay-on-energize ranging from 0.05 to 60 seconds. External components are not required. The units have pin spacing for a DIP layout, and can either plug into a socket or mount directly on a printed-circuit board. Though delays are fixed at specified set points,

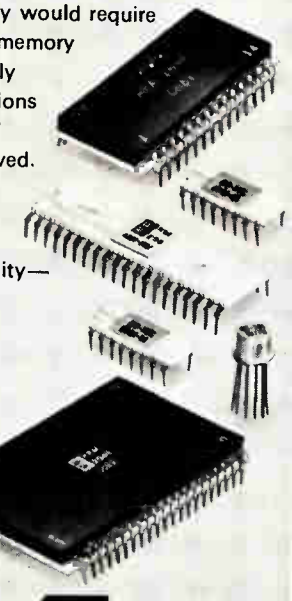




Let's talk about Mechanical Memories...

Ever wondered why so many control systems still rely on mechanical and electromechanical components to perform "memory" functions? Why they haven't switched over to reliable solid-state electronics—*yet*?

It's because performing such functions electronically would require two essential characteristics in a single solid-state memory system: (1) It *must* be quickly, easily and selectively reprogrammable to accommodate a variety of functions and function changes. And (2) it *must not* "forget" what it's supposed to do every time power is removed. Then, of course, there's the matter of cost.



Now—how many semiconductor memories are there on the market today that offer true non-volatility—plus selective, repetitive electrical alterability—plus non-destructive readout—all combined in a single, low-cost, integrated array?

Just one! And it's available now in standard units ranging from 8-bit up to 2048-bit arrays that can readily be configured to meet your particular requirements.

AMORPHOUS

RMM

Non-Volatile/Repetitively Alterable Semiconductor Memory Arrays

If you'd like to know first-hand how RMMs can be used to improve your product's reliability, versatility and cost, our Systems Engineering Group will gladly evaluate your application and submit detailed recommendations. Just call or write Howard Klausmeier at:

ECD

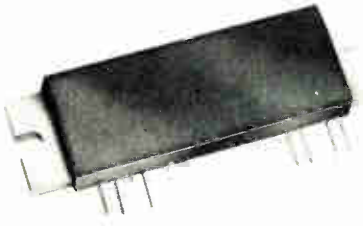
RMM DIVISION
Energy Conversion Devices, Inc.
1675 WEST MAPLE ROAD • TROY, MICHIGAN 48084
TELEPHONE: 313/549-7300

New products

offset binary coding. Prices for the converters start at $99.
Datel Systems Inc., 1020 Turnpike St., Canton, Mass. 02021 [387]

Uhf power amplifiers deliver to 15 watts

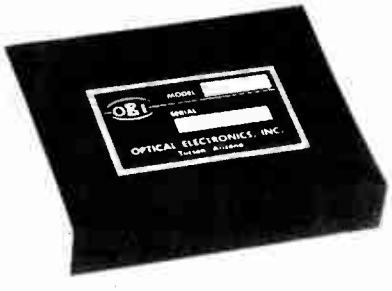
Three integrated uhf power amplifiers deliver 10, 13 and 15 watts respectively at 470 megahertz. They are designated the models R47M10,



R47M13 and R47M15 and operate across the range of 440–470 megahertz with 20-decibel gain. Price in lots of 100 for the 10-watt version is $31.20. The 13-watt and 15-watt units are $36 and $42 respectively.
RCA Solid State Division, Box 3200, Somerville, N.J. 08876 [388]

A-d converter offers 20-ns throughput delay

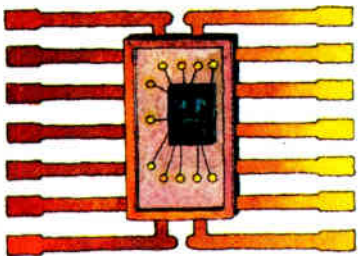
The model 7530 4-bit analog-to-digital converter is for use in radar, video, and laser range-finding systems. Features of the device include a maximum throughput delay of 20



nanoseconds, a 50-MHz minimum word rate, and Schottky-TTL output. Price is $195 each for one or two units, $175 each for three to nine units, and $158 each for 10 to 29 pieces.
Optical Electronics Inc., Box 1140, Tucson, Ariz. 85734 [389]

GREATEST YIELD IN THE ELECTRICAL FIELD

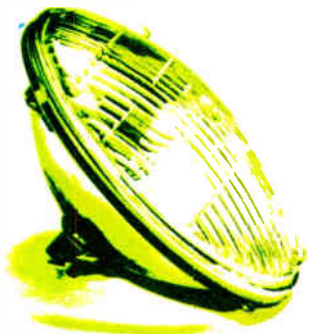
ALLEGHENY LUDLUM STEEL GIVES YOU MORE FOR YOUR MONEY



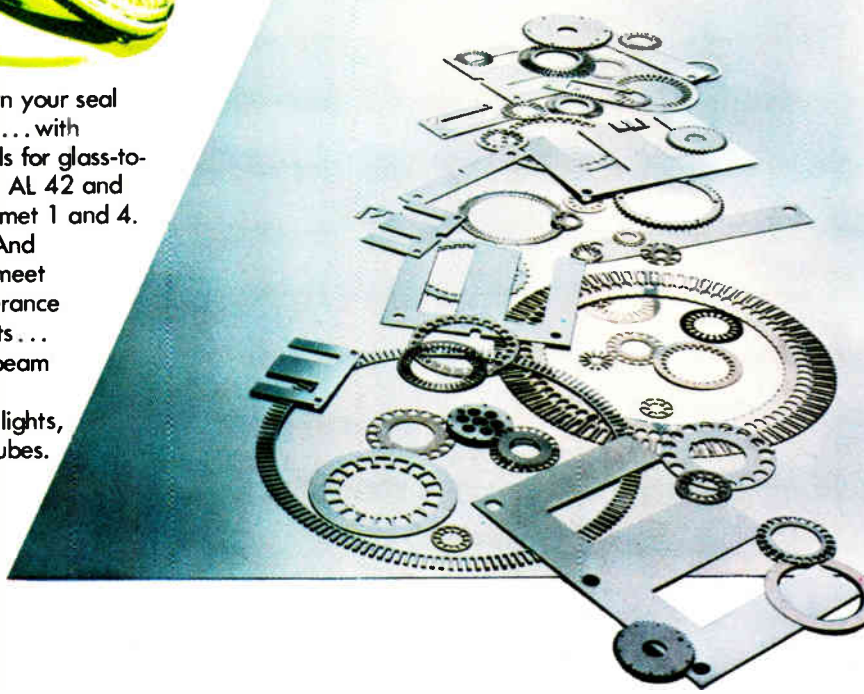
Critical demands for leadframes in semiconductors are more than semifilled by Allegheny Ludlum. Our product range and consistently high quality fill numerous needs.

Wider strip? In widths up to 25 inches, our electrical alloy strip yields more good parts faster to cut costs. Sheet? Plate? Bar? Get the best . . . for laminations and shieldings. Motors. Transformers. Generators. Relays. Solenoids. Vibrators. Cores. Check our Sealmet alloys. Or Ohmaloy. Mumetal. Moly Permalloy, etc.: all products of strict A-L quality control . . . from computerized melting to final shipment . . . for consistently superior characteristics.

A pioneer in developing magnetic shielding materials, we stock Mumetal and Moly Permalloy for prompt delivery. Our Research Center, most elaborate in stainless and specialty alloys, helps solve special shielding problems.



We can earn your seal of approval . . . with special steels for glass-to-metal seals: AL 42 and 4750. Sealmet 1 and 4. AL 430Ti. And others. All meet tightest tolerance requirements . . . for sealed-beam headlights, fluorescent lights, electronic tubes.



For more on how America's leading producer of stainless and specialty alloys can help you in the electrical field, write: Allegheny Ludlum Steel, Dept. 331, Oliver Building, Pittsburgh, Pa. 15222.

Allegheny Ludlum Steel
Division of Allegheny Ludlum Industries

No-Problem Memory

Looking for a high-speed memory that won't give you any problems? Look at our Micromemory 3000. It's a reliable 3 Wire, 3 D core memory with a complete cycle time of 650 nsec, and 300 nsec access.

Not only does the Micromemory 3000 give you core reliability and low cost, but the compact convenience of a complete memory system—including all required logic, drive and sense circuitry—on a single printed circuit card. Maximum capacity per card is 8K by 18 bits, or 16K by 9. But you can stack the cards to get any size system you need. Or we'll do it for you.

In fact, the unit shown is our standard Micromemory 3000 chassis. It can accommodate up to four individual memory cards plus power supply, self-test or interface cards and other features. Yet it is only 5¼-inches high, and fits a standard 19-inch rack. Other chassis holding up to 16 cards are also available.

With over two years' field experience, the Micromemory 3000 is so popular we are producing them at the rate of 6000 a year. Combine this proven reliability, high performance and low cost in your next memory system. Write or call Mel Zeramby at (213) 644-9881 for all the details.

ELECTRONIC MEMORIES
COMMERCIAL PRODUCTS
A Division of Electronic Memories & Magnetics Corporation
12621 Chadron Ave., Hawthorne, Calif. 90250

P&B's compact R10 relays help you solve more application problems than with any other relay.

Relays shown actual size.

Our R10 relay series offers designers a whole family of AC and DC industrial relays that combine extraordinary versatility of application, the reliability of telephone-type relays, plus small size (less than a cubic inch). They are widely used in copiers, computer peripherals, business machines, and precision instruments.

These relays have so many options that each model may literally be designed by you to meet your particular needs. This single family of relays, with many common mechanical dimensions and mounting techniques, cover the whole range of switching loads from dry circuit to 10 amperes, 28 VDC, 120 VAC. There are terminal styles for octal plug, solder, or pc board mounting. And, sockets multiply design options even more.

R10 relays can be ordered with Form A, B, C and D contacts and up to 8 Form C. Recognized by Underwriters Laboratories under file 42810. R10 relays have a continuous power dissipation of 2.2 watts maximum. Standard sensitivity is 125 milliwatts per pole (more sensitive units available on special order). Electrical life ranges from 100,000 to 100 million operations.

For complete information on R10 industrial relays, call your local P&B Representative. Or, call or write Potter & Brumfield Division AMF Incorporated, Princeton, Indiana 47670. Telephone 812 385 5251.

FREE PUZZLE*

Arrange the pieces so that no color or shape is duplicated in any row, column, or either diagonal. As an engineer, you should solve this puzzle in 27 minutes.

Like to try your hand at solving the puzzle shown above? Ask your P&B representative for one.

*"Bali-Buttons". © Behavioral Sciences, Inc.

Solving switching problems is what we're all about.

AMF

Potter & Brumfield

Circle 169 on reader service card

FREON* (BLACO-TRON**)

A ~~rose~~ by any other name will clean as well.

Why shouldn't BLACO-TRON precision cleaning solvent clean the same as FREON: Their chemical formulas are identical.

DuPont calls their trichlorotrifluoroethane "FREON" TF. We call ours "BLACO-TRON" TF. So now you have a choice.

If they're identical, why should you try BLACO-TRON? Service. The service you get only from Baron-Blakeslee—for 38 years the accepted leader in advanced design precision cleaning equipment and the solvents to go in them.

In fact, chances are good that the machine you are now using to clean with FREON was developed by Baron-Blakeslee!

Exercise your right to choose a cleaning agent that is the chemical equal to FREON—with the plus value of Baron-Blakeslee expertise. Pick up the phone and contact your BLACO-TRON Distributor now . . . he offers a full line of BLACO-TRON fluorosolvents.

BLACO-TRON
FLUORINATED SOLVENTS—NOW THERE IS A CHOICE

Baron-Blakeslee 1620 South Laramie Ave., Dept. FE, Chicago, Ill. 60650—Offices in All Principal Cities.

*FREON is DuPont's registered trademark for its fluorocarbon cleaning agents.

**BLACO-TRON is Baron-Blakeslee's registered trademark for its fluorocarbon cleaning agents.

Circle 170 on reader service card

New products

Instruments

ROM programer sets bits fast

Three models in line include automatic verification, LED display

Along with the growing use of programable read-only memories in microcomputers and other equipment has come the need for instruments to program them. The model 810 ROM programer, made by Pro-Log Corp., is designed to program the Intel 1702A erasable 2,048-bit ROM, either from the instrument's internal keyboard or from a master ROM.

A similar programer, model 811, is for the Microsystems International Ltd. 1702 chip, and the Pro-Log model 812 is designed for the National Semiconductor 5203 ROM.

The 1702 is organized into 256 words of 8 bits each, and the programer can program a ROM from the hexadecimal keyboard in about 15 minutes. Duplication of that ROM then takes about 20 seconds or longer, depending on the content. In addition to programing, the instrument can automatically verify that a ROM matches a reference. A light-emitting-diode display will verify the content of each addressed word. Words are displayed in four-digit hexadecimal, with addresses in 8 bits.

The unit can also program a ROM that is not quite identical to a reference but has changes in certain addresses. It will store up to 16 changes per ROM before proceeding with the programing.

The controller for the 810 is a programed logic system itself and is adaptable to operation from a teletypewriter, a paper-tape reader, and other equipment. An ultraviolet light will erase ROMs for reprograming. Quick-load, zero-insertion-force sockets are used for the ROMs, and the instrument operates from either 110 or 220 volts at 50 watts.

The instrument is packaged in an 18-by-12-by-4.5-inch attache case weighing 15 pounds.

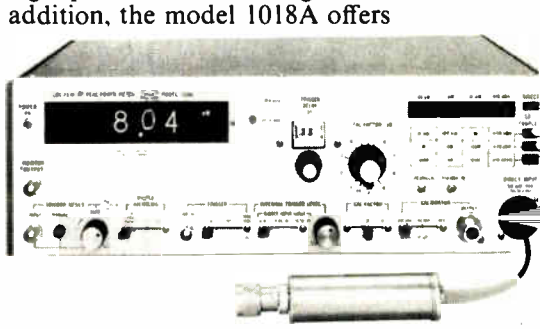
Options include the ultraviolet light source, paper-tape reader and teletypewriter. The teletypewriter interface permits programing with an ASR-33, including using its paper-tape reader and punch, or read-out of programs stored in paper or on tape. Normal code is ASCII, with hexadecimal characters.

The 810 ROM programer has a price tag of $1,900.

Pro-Log Corp., 2826 Metropolitan Pl., Pomona, Calif. 91767 [351]

Rf power meter measures pulses and continuous wave

An rf power meter, designated the model 1018A, measures the peak power of radio-frequency pulses in addition to measuring continuous-wave power. The measured pulse may be a single isolated pulse or individual pulses in a train. The instrument handles pulses lasting 0.20 microsecond and longer, and pulse repetition frequency can range from a single pulse to above 1 megahertz. In addition, the model 1018A offers



New products

a cw frequency range from 100 MHz to 12.4 gigahertz. An option permits measurements to 18 GHz, and a data-output option is also available. Price of the basic model is $3,500.
Pacific Measurements Inc., 940 Industrial Ave., Palo Alto, Calif. 94303 [352]

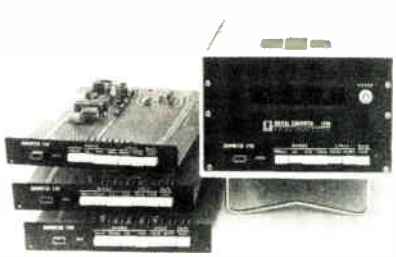
Digital multimeter offers 1-microvolt sensitivity

A fully autoranging five-digit multimeter offers a 1-microvolt sensitivity, four ac ranges with 10-μV sensitivity, five ranges of dc ratio, four ranges of ac/dc ratio, and six resistance ranges from 1 milliohm full scale to 12 megohms full scale. For users who do not require the extra

capability, the ac and dc ohms converter can be dropped, so that price of the instrument with full capability is $995, while the unit without converter is $795. The meter has an input resistance of 10,000 megohms.
Cimron Instruments, Lear Siegler Inc., 714 N. Brookhurst, Anaheim, Calif. 92903 [353]

Plug-in modules measure low resistance ranges

The model 1700 resistance measurement system consists of a digital converter and four ohmmeter plug-in modules, each with a different measurement range: to 20 ohms with resolution to 1 microhm, to 200



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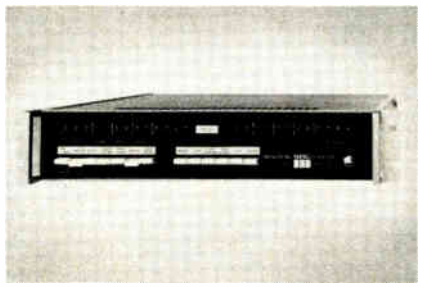
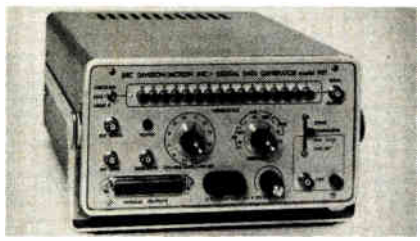
New Time Code Translator/Generator — Precision unit provides *simultaneous* and *independent* generation and translation of any time code format. All modular plug-in design and wire-wrap interconnection eliminates "mother boards" for easier maintenance and field modification. Seven-segment gas discharge displays present outstanding readability. Days, pulse rate and parallel outputs are standard.
MOXON/SRC CIRCLE **208**



New Search and Control Unit — Fully automatic, self-contained unit controls magnetic tape transport. It features multiple search modes for wider system applications plus adjustments for best search operation characteristics. Auxiliary outputs included for control of data reduction processes. Plug-in circuit boards replace difficult to service "mother boards."
MOXON/SRC CIRCLE **209**



New 16-BIT Digital Generator for Bread-Board Testing — Simple-to-operate Model 901 has three power supplies built-in for fast, easy broadboard testing (0 to 7 VDC, 0 to +15 VDC and 0 to −15 VDC). Latching pushbutton switches quickly program 16 digital bits in serial, dynamic parallel or "hard-wired" parallel form. Outputs offered are repetitive, non-repetitive and popular "walking" combinations. Rates to 15 MHz.
MOXON/SRC CIRCLE **210**

SRC

Moxon Inc/SRC Division
2222 Michelson Drive
Irvine, California 92664
Phone: (714) 833-2000

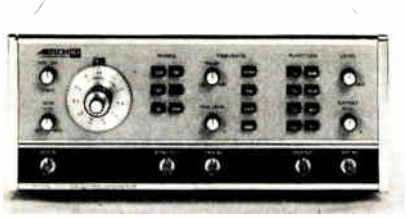
New products

ohms with resolution to 10 microhms, to 2 kilohms with resolution to 100 microhms, and to 20 kilohms with resolution to 1 milliohm. Positive or negative logic and the plug-ins needed are left to the customer to specify. Price ranges from $350 to $850.

Electro Scientific Industries Inc., 13900 N.W. Science Park Dr., Portland, Ore. 97229 [354]

Function generators have 20-MHz capability

A 20-MHz function generator, part of the company's Gold Line Series, includes output amplifiers with 3-decibel limits above 60 MHz. In addition, rise time is specified at 10 nanoseconds, with 7 ns being typical. Output range is 24 volts peak-to-peak open circuit, 12 v peak-to-peak into 50 ohms. Other specifications are 5% to 95% symmetry control,



output frequencies down to 0.02 hertz, and a 0-80-dB attenuation range. Waveforms include triangle, sine, square, pulse, and sawtooth, with or without offset. The model 520 is priced at $695, and the model 521 with trigger and gating sells for $795.

Ailtech, 19535 E. Walnut Dr., City of Industry, Calif. 91748 [355]

Portable oscilloscope offers dc to 20 megahertz operation

Providing dc to 20 megahertz wideband operation, a miniature line- or battery-operated portable oscilloscope, the model PS010A, offers a vertical sensitivity of 10 millivolts per division and a time base of 100 nanoseconds to 100 milliseconds per division. Batteries are internal and

Toggle switches that help do everything from nab a speeder to catch a heartbeat.

Think MICRO SWITCH when you're in the market for toggle switches.

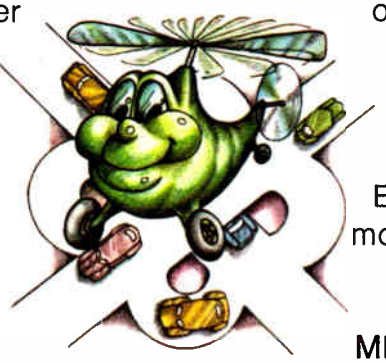
Right now, our devices are in use on everything from electronic speed calculators(TW) to an electrocardiograph(AT). in other words, just about every application where precise operating characteristics and reliability are important.

Both features are built into our complete line. From our inexpensive Series 8 to our moderately-priced TL. So no matter how demanding your application is, you can feel confident of getting the right switch for your job.

We offer a broad selection of circuitry, size, electrical capacity, sealing and toggle action, as well as UL listed and military-approved versions. There's also a choice of over 60 different levers to help you customize your panel.

This allows design freedom that has been put to use in some unusual places. For example, the next time you're tuned in to a traffic report, there's a good chance our TL and ET environmentally-sealed switches will be helping the traffic copter help you.

Let one of our Application Engineers help you with your application. Contact your MICRO SWITCH Branch Office or Authorized Distributor (Yellow Pages, "Switches, Electric") for more information.



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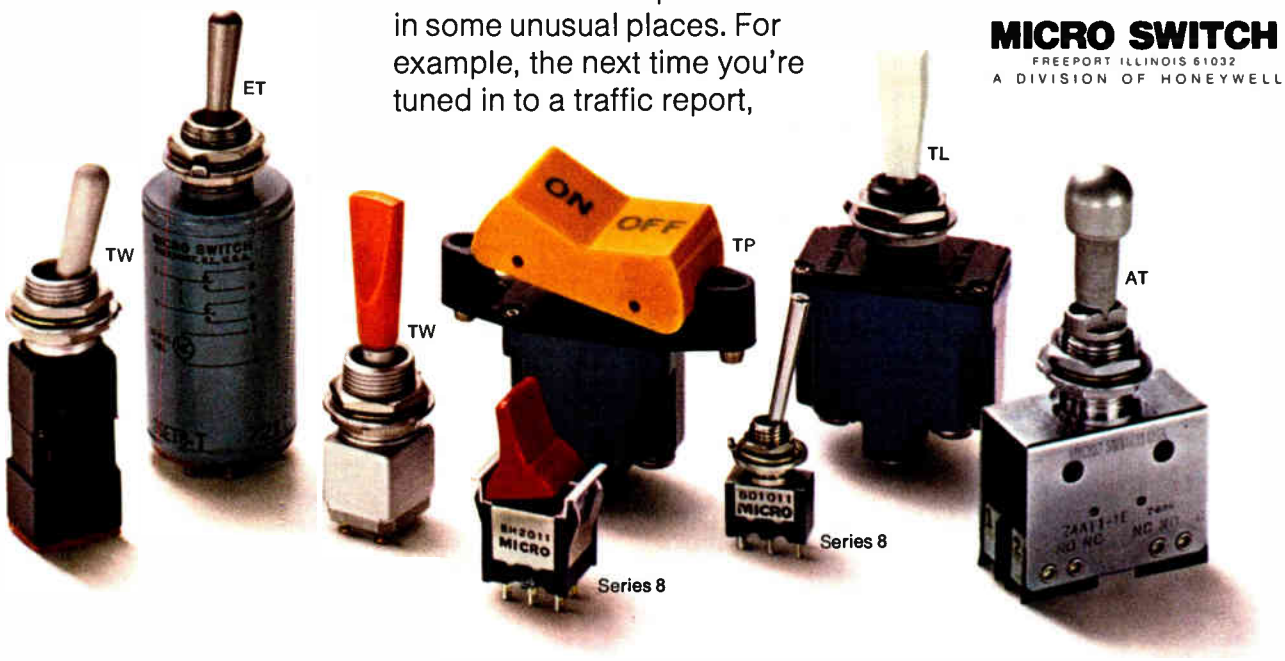
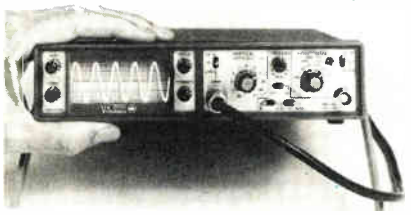


MICRO SWITCH products are available worldwide through Honeywell International.

New products

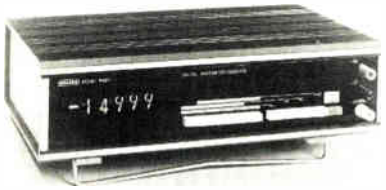
may be nickel cadmium, alkaline or flashlight cells. Up to five hours' operation can be obtained from nickel-cadmium types. Price of the portable scope is $595, and delivery time is 30 days.



Vu-Data Corp., 7170 Convoy Court, San Diego, Calif. 92111 [356]

Multimeter-counter simplifies calibraton

Designed for field service and laboratory use, a 4½-digit multimeter-counter offers ac and dc voltage measurement, as well as resistance and frequency measurement. Nor-



mally, such a meter would require 17 calibration points, one for each scale, but this model's circuit commonality makes it possible to reduce them to 12 points. Price of the instrument is $695.

California Instruments, 5150 Convoy St., San Diego, Calif. 92111 [357]

Multimeter can measure up to 500 volts dc

A multimeter designed with field-effect-transistor circuitry is designated the model WV-530A. The unit can measure up to 500 volts dc in six ranges and up to 500 v ac in four ranges. Input resistance is 10 megohms on all dc ranges, and accuracy is to within ±3% of full scale. The unit also measures up to 1,000 megohms in four ranges and ac voltages at frequencies up to 50 kHz. Dc cur-

Comparator Supermarket

Variety that lets you pick exactly what you need.

SIGNETICS COMPARATOR SELECTION LIST								
Check Need	Part Type	Operating Supp Range (V)	TTL Fan Out Capability	I Offset (μA)	I Bias (μA)	V Offset (mV)	Propagation Delay (nS)	
							Typical	Maximum
	NE521	±5	10	5.0	20.0	7.5	8	12
	NE522	±5	10	5.0	20.0	7.5	10	15
	NE526	±5	10	5.0	35.0	5.0	40	48
	NE527	±5 to ±12	10	0.75	2.0	6.0	16	26
	NE529	±5 to ±12	10	5.0	20.0	6.0	12	22
	μA710	+12, −6	1	5.0	25.0	5.0	40	—
	μA711	+12, −6	1	15.0	100.0	5.0	40	—
	LM311	+5, GND to ±15	5	0.05	0.250	7.5	200	—

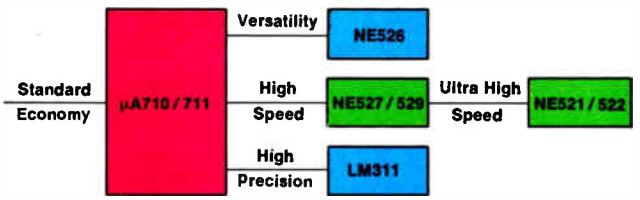
Life sweetens a little. When you can get everything in comparators, from the fastest TTL to the finest precision with one call, you save a lot of migraine and a lot of bucks.

The chart also tells you something else. You can choose exactly the device you want for each of many different requirements. So you can optimize your systems, which gives you one kind of economy. And you can combine your comparator orders to get more economy. Known as smart-money thinking.

Say one of your interests is speed. You look at the four listed comparators that go from the NE527 with 16nS propagation delay down to the NE521, an 8nS dual. That's a spectrum you'd be looking in if you're building MOS memory sense amps, or maybe a Schottky line receiver.

If you turn around and go to the other end, precision, the nastiest you'll probably specify is the LM311. When you want it, you've got it.

The middle ground is where you trade off. For speed versus precision, as in glitchless voltage comparison and peak detection, the versatile NE526 hits the right balance. If it's straight price you're fighting, for applications that are pretty much standard, grab the μA710/711.



It just makes sense for a supplier of comparators to build the full line in quantity. Signetics figures it ought to make the same sense to a design engineer to check first with the supplier who has that philosophy.

So check. The left hand column is reserved for you.

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I'm sending the coupon instead of the "bingo card" because I'd like some technical details reasonably promptly. Please send the data sheets on the full comparator line, plus any applications information you have lying around.

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signetics

New products

rent is measured to 500 milliamperes in three ranges. Price is about $59.90.

RCA Electronic Components, 415 S. 5th St., Harrison, N.J. 07029 [358]

Preamplifier increases sensitivity of recorders

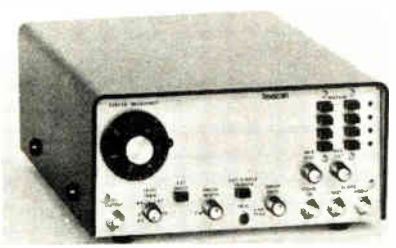
The model 20 portable preamplifier is designed to increase the sensitivity and resolution of graphic recorders, oscilloscopes, and meters. It provides gain in 10 steps from 1 to

1,000, including zero-check and built-in suppression for up to ±100 mV in two steps, with dual polarity and digital vernier for repeatability. The increase in sensitivity, plus suppression of dc offsets, enhances signal resolution. Price is $396.

Fogg System Co. Inc., 1380 S. Dahlia St., Box 22226, Denver, Colo. 80222 [359]

Sweep generator covers from 1 to 500 megahertz

The model WB-711 is a sweep generator covering from 1 to 500 megahertz in one band. Specifications include: impedance of 50 ohms, power output of 10 dBm, sweep rate of 0.5 to 60 hertz, flatness of ±0.25

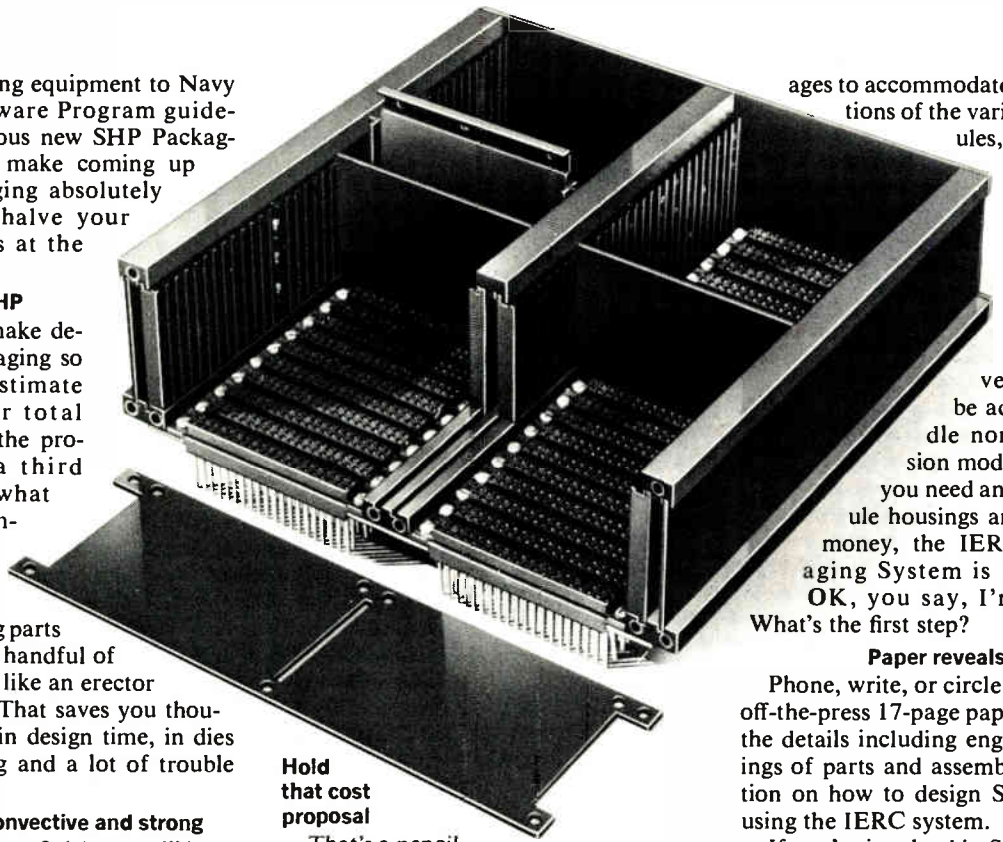


dB, and a sweep width of 0.1 to 500 MHz. Price is $735.

Texscan Corp., 2446 N. Shadeland Ave., Indianapolis, Ind. 46219 [360]

Announcing standard off-the-shelf SHP packaging components . . .

Navy Standard Hardware Program packaging made easy and profitable



If you're supplying equipment to Navy Standard Hardware Program guidelines, our ingenious new SHP Packaging System will make coming up with the packaging absolutely simplistic and halve your packaging costs at the same time.

No sweat SHP

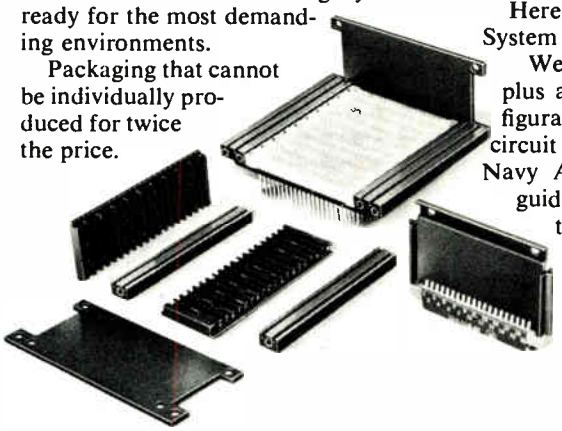
First off, we make designing the packaging so effortless we estimate you'll cut your total design load for the procurement by a third because that's what our first customers are experiencing.

Production consists of putting parts together – just a handful of different kinds – like an erector set. Only easier. That saves you thousands of dollars in design time, in dies and other tooling and a lot of trouble to boot.

Conductive, convective and strong

And when you get finished you'll have packaging for your circuitry with the high order of thermal efficiency you'd expect from industry's leading manufacturer of circuit heat dissipating devices. Plus mechanical integrity that's ready for the most demanding environments.

Packaging that cannot be individually produced for twice the price.



Hold that cost proposal

That's a pencil-sharpening fact you can ill afford to ignore if you're in the middle of preparing a proposal in response to an RFP that calls out SHP – or if you ever expect to bid an SHP program.

Here's how our new SHP Packaging System works:

We've designed six basic parts – plus a few specials for unusual configurations – with which you can build circuit module housings conforming to Navy Avionics Facility, Indianapolis, guidelines and dimensions for any of the common SHP-defined circuit modules using nothing but a screwdriver.

Ad infinitum

You can build these packages to accommodate any combinations of the various SHP modules, and the potential dimensions of the packaging in span and depth are for practical purposes limitless.

In fact, our system is so versatile it can be adjusted to handle non-SHP-dimension modules as well. If you need any kind of module housings and like to save money, the IERC SHP Packaging System is for you, too.

OK, you say, I'm interested. What's the first step?

Paper reveals all

Phone, write, or circle to get our hot-off-the-press 17-page paper that gives all the details including engineering drawings of parts and assemblies and a section on how to design SHP packaging using the IERC system.

If you're involved in SHP or ever expect to be, get involved with the IERC SHP Packaging System today.

Ask about our SHP module plates including our revolutionary Metal Core Circuit Board plates for extremely high power densities, too. International Electronic Research Corporation, a subsidiary of Dynamics Corporation of America, 135 West Magnolia Blvd., Burbank, Calif. 91502. (213) 849-2481.

IERC DCA

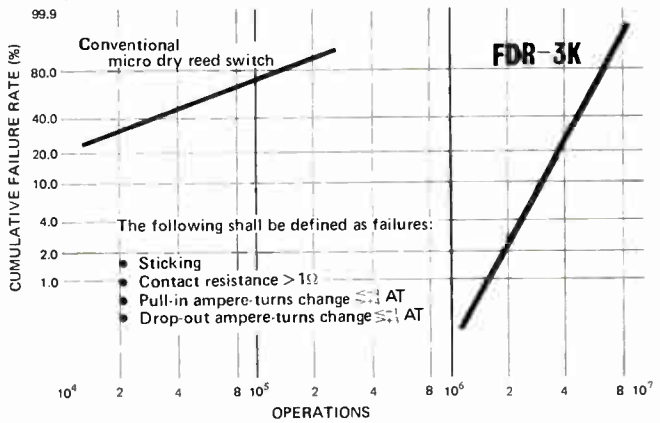
Heat Sinks/Dissipators

The Fujitsu Quality for Sale in Reed Switches.

FUJITSU Fujitsu Reed Switches are ultra-miniature with high performance, as shown in Table 1.

FDR-3K was especially designed for use in higher level electrical loads (at 100V AC, 0.5A resistive load), providing high reliability and long life (10^6 operations) even though no larger than conventional micro dry reed switches.

Heavy load life test characteristics (100V AC 0.5A resistive load)



<Table 1> Fujitsu micro reed switch series

Reed Switch	Contact Form	Contact Rating	Pull-in Ampere-Turns	Drop-out Ampere-Turns	Operate Time	Release Time	Initial Contact Resistance	Dielectric Withstanding Voltage
FDR-3K	A(make) Center Gap	30VA DC (1A max) 50VA AC (1A max)	20~60	8 min.	800μs max. including contact bounce	50μs max. including contact bounce	150mΩ max.	500V DC (1 min)
FDR-3	A(make)	10VA DC						
FDR-4	Center Gap	0.5A DC max. 100V DC max.						350V DC (1 min)
FDR-7	A(make) Off-set Gap		20~52	10min.				
MEMOREED FDR-8	Self-latching Type	5VA DC (0.5A max)	85±10/ 110±10	−28±5/ −24±10	1.5ms.	0.1ms.	100mΩ max.	600V/ 800V DC (1 min)

- Over-all length: 56mm(FDR3K, FDR-3) 44.2mm(FDR-4), 40mm(FDR-7), 45mm(FDR-8)
- Glass length: 21.5mm (FDR3K, FDR-3) 16.5mm(FDR-4), 15.0mm(FDR-7), 25mm(FDR-8)
- Glass diameter(max): 2.7φmm(FDR3K, 3, 4, 7and 8)
- MEMOREED: Self-latching Reed Switch

FUJITSU LIMITED
Communications and Electronics
Marunouchi, Tokyo, Japan

For further information, please contact:
Head Office: 6-1, Marunouchi 2 Chome, Chiyoda-ku, Tokyo 100, Japan Telex: J22833
New York: 680 Fifth Avenue, New York, N.Y. 10019, U.S.A. Phone: (212) 265-5360
Fujitsu California Inc.: 1135 East Janis Street, Carson, California 90746, U.S.A. Phone: (213) 636-0858,(213) 537-8930

MAIN PRODUCTS □ Telephone Exchange Equipment □ Carrier Transmission Equipment □ Radio Communication Equipment □ Space Electronics Systems □ Electronic Computers & Peripheral Equipment (FACOM) □ Telegraph & Data Communication Equipment □ Remote Control & Telemetering Equipment □ Electronic Components

Profits in motion for communications equipment

You can reduce assembly and inventory costs, get reliable total functions in minimum space, and obtain application help when you ask TRW/Globe to build your motion package.

Four builders of communications equipment can affirm this from their experience with the packages on this page.

1. TRW/Globe supplies this complete cassette drive module for a telephone answering system. The customer avoids assembly costs as well as the problem of aligning the two output shafts.

2. This blower was built to fit the space available after most of a military transceiver had been designed. TRW/Globe also helped the customer determine the system's resistance to air flow.

3. TRW/Globe meets all functional requirements in this rotary actuator for switching bands on a military transceiver. The package includes gearing, limit switch, mechanical stop, slip clutch, electro-mechanical brake, and filter.

4. This package drives the scanner in a facsimile transceiver. TRW/Globe's experience with hysteresis synchronous motors assures that both the transmitter and recorder will be synced.

To get your profits in motion, call or write: TRW/Globe Motors, an Electronic Components Division of TRW Inc.. Dayton, Ohio 45404 (513-228-3171).

TRW® GLOBE MOTORS

The Brazed Magnetron Anode Is Dead.

Hitachi Patent Nos. 3,678,575 and 3,719,068 for Manufacturing Magnetron Anodes Now Available for Licensing.

DEFORMATION PROCESS

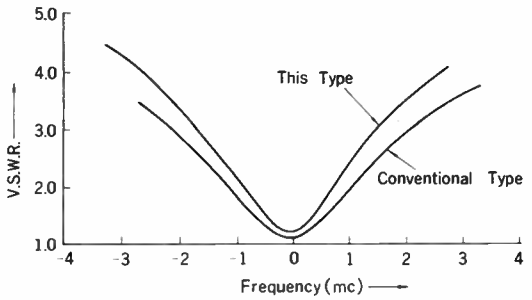


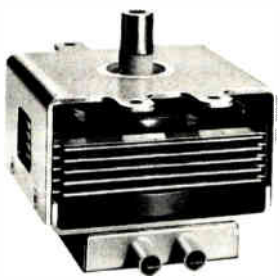
DIAGRAM OF Q FACTORS

Hitachi is opening up thousands of its patents. And, where it's needed, backing up the patents with the suitable technology. We'd like to tell you about a process for manufacturing magnetron anodes that may be of interest to you.

Hitachi U.S. Patent Nos. 3,678,575 and 3,719,068 applies to our process for mass producing magnetron anodes. And at the same time improving their quality.

By applying a preliminary plastic deformation to the metal stock, the plastic flow of material is facilitated during subsequent press work. Consequently, we are able to press out magnetron anodes by employment of a special processing procedure to the conventional cold hobbing process.

Our patents mean that you can stop the costly brazing of vanes to the outer wall of the anode. It means that you can attain working accuracy within 0.05mm (two times better than by conventional methods). That you can improve the overall quality of your anodes by as much as 32%. And that you can decrease cavity loss by as much as 30%.



Finally, it means that by mass production you can lower the cost of your magnetron anodes by up to 50%.

To find out more about Hitachi's cold hobbing process for manufacturing magnetron anodes, please write us at the address below.

HITACHI

Hitachi, Ltd.
Area section A (Patent Group)
International Business Operations Division
6-2, 2-chome, Ohtemachi, Chiyoda-ku,
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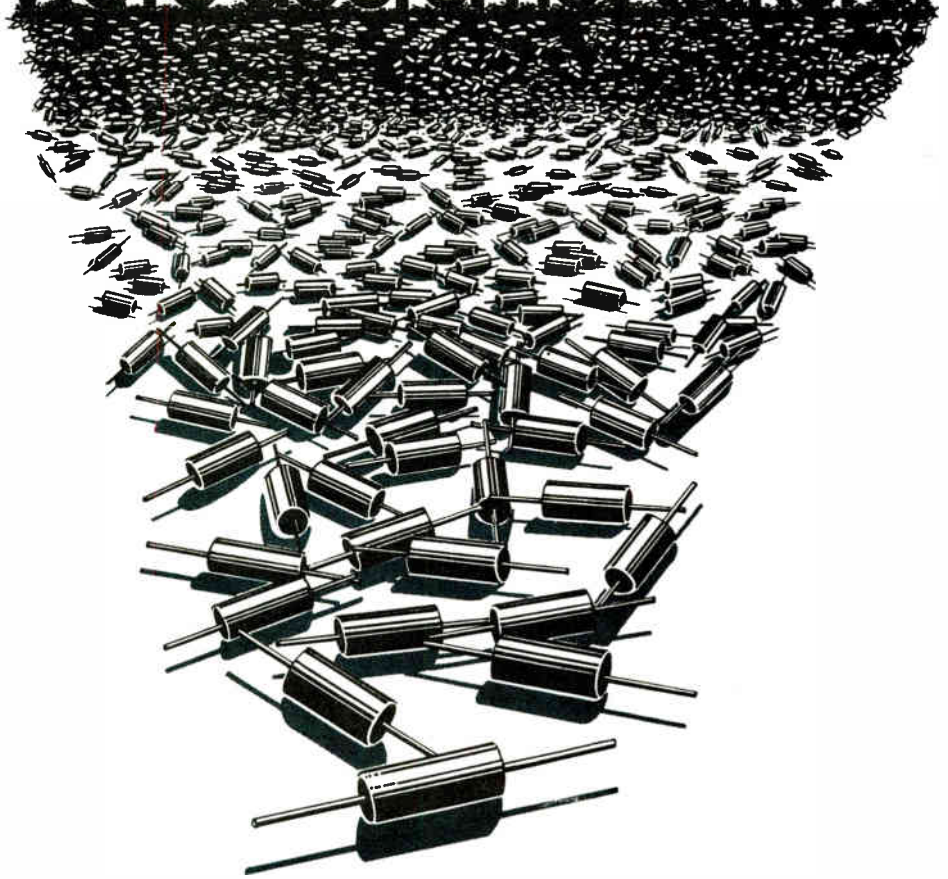

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Circle 183 on reader service card 183

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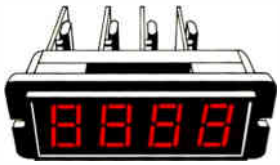
Each digit in this bezel assembly contains a Dialight light-emitting diode, decoder/driver, and resistor network that produces a bright, highly visible readout that can be easily installed in a panel. The readout display is supplied with discrete gallium phosphide or gallium arsenide phosphide diodes arranged in a seven-segment format. These generate a bright, highly legible red character (0.625 inch



high—the largest size character in the industry) with the lowest power consumption for a character of this size. Ideal for mounting on a control panel, or in a digital clock, meter, credit-card verifier, TV channel indicator, or hospital room status-board indicator. The contrast ratio between the illuminated and non-illuminated segments is further enhanced by a one-piece red nonglare window.

New products/materials

Designated Eccobond 286, a two-part room-temperature curing epoxy adhesive contains no solvent. It is 100% reactive, and is offered in a collapsible squeeze-tube kit. Equal volumes of each part are squeezed out on any suitable surface and mixed together with a mixing stick supplied in the kit. Then, a thin layer of the mix is applied to the two surfaces to be bonded. In most cases contact pressure is sufficient to hold the two parts together. Cure is complete in 24 hours, but bonded articles may be handled after two to four hours. Price is $3.50 per pound in an 11-pound kit.
Emerson & Cuming Inc., Canton, Mass. 02021 [476]

An electroless nickel-plating composition called Enpat is for making ohmic contacts to p- and n-type silicon. Properties of the material include: a pH of 10, electrode potential of 0.44 volt at 95°C, and an operating temperature of from 90° to 95°C. Price is $15 per gallon and $8.50 per gallon in quantity.
Transene Co. Inc., Rte. 1, Rowley, Mass. 01969 [477]

Copper-clad glass-fiber laminated epoxy is available in shapes other than flat sheets on open stock tooling. The material is 155°C glass epoxy per MIL-R-9300 and MIL-C-9084, and the copper is 1-ounce foil bonded to the inside of the tubing. Applications include radio transmitters and receivers and contoured circuit boards.
Stevens Tubing Corp., 128 N. Park St., East Orange, N.J. 07019 [478]

Alumina ceramic parts are fabricated on a custom basis to print. The 94% alumina parts are good for subsequent metallizing, using a wide range of compounds such as moly-manganese and moly-titanium. The parts are available in diameters up to 1 inch, and 1-by-1-inch lengths and widths.
Glass Beads Co., Box 266, Latrobe, Pa. 15650 [479]

A series of urethane UE systems are for coating, potting, and casting low-stress encapsulation. The systems are completely blocked and are adapted to outdoor and cold climates. Moreover, they are nontoxic, are moisture-resistant, and contain no amines or volatiles. Price ranges from $1.30 to $2.60 per pound.
Isochem Resins Co., Cook St., Lincoln, R.I. 02865 [401]

Two compatible chemicals, Organo Flux CF-430 and Fusecote 240, become water-soluble for removal after solder reflow. Organo Flux is chlorine-free and is used for the fluxing of circuit boards to be reflowed, and Fusecote is for tin-reflow operations and is biodegradable.
London Chemical Co. Inc., 240 Foster Ave., Besenville, Ill. 60106 [402]

A screen-printable crystallizing protective overglaze is for use with resistor and capacitor dielectrics. Called Overglaze 99, the material is a hard-surface, clear insulator in ready-to-use form. Firing condition is 5 to 15 minutes at 560°C in an air atmosphere. Voltage stability is greater than 500 V, and price is $10 per ounce in quantity.
Electro Materials Corp. of America, 605 Center Ave., Mamaroneck, N.Y. [403]

Ceramacoat 518 and 512 are materials that allow a coating of ceramic to be applied to epoxy plastic structures as a thermal insulation barrier, with temperature limits up to 2,500°F. Material 518 is a silica ceramic epoxy paint that is applied as a prime coat to the epoxy structure and cured at 280°F before having Ceramacoat 512, an all-silica-ceramic coating, applied over it. Ceramacoat 518 is available in 1-quart kits at $30 each; 512 at $40.
Aremco Products Inc., Box 145, Briarcliff Manor, N.Y. 10510 [404]

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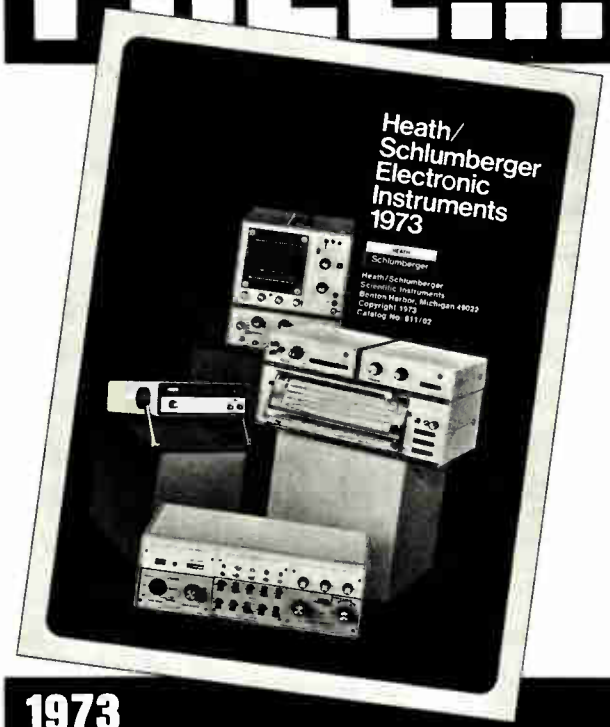

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Circle 227 on reader service card

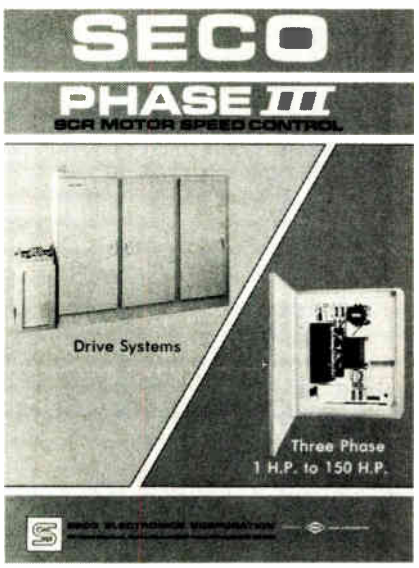
New literature

Reed relays. Electronic Instrument & Specialty Corp., 42 Pleasant St., Stoneham, Mass. 02180, has issued an eight-page catalog covering the spectrum of reed-relay technology from DIP to axial relay types. Circle 421 on reader service card.

Filters. Catalog sheets from BG Electronics, 9 Elm Ave., Mount Vernon, N.Y. 10550, describe filters for both telegraph and voice transmission. [422]

Testers. An application note describes how electrodynamic vibration generators are used to increase the reliability of electronic products subjected to vibration. It is available from Booth Development Inc., 128 Short Dr., Short Beach, Conn. 06405 [423]

Drive controls. Seco Electronics Corp., 1001 Second St. South, Hopkins, Minn. 55343. A 16-page catalog describes three-phase SCR drive controls. Specifications and descriptive information are provided on the models 4230 and 4430 Phase III controls. [405]



Soldering compounds. Force Chemicals Division, American Solder and Flux Co. Inc., Industrial Blvd., Paoli, Pa. 19301, is offering a six-page catalog describing the line of paste solders, soldering fluxes, silver bearing solder, and related soldering and trimming products that are manufactured by the company. [440]

LED displays. Eldema Division, Genisco Technology Corp., 18435 Susana Rd., Compton, Calif. 90221, has published a four-page data sheet describing the line of wide-angle, large-character model 135-3870 LED displays. [438]

Logic cards. A brochure describing the L series of LSI functional logic cards for designing general- and special-purpose minicomputers is available from Control Logic Inc., 9 Tech Circle, Natick, Mass. 01760 [439]

Amplifier. A two-page data sheet from Datel Systems Inc., 1020 Turn-

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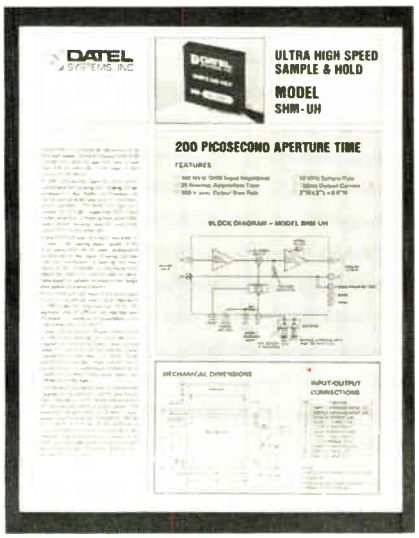
pike St., Canton, Mass. 02021, describes the specifications of the



model SHM-uH sample-and-hold amplifier. [437]

Reed relays. Electronic Instrument & Specialty Corp., 42 Pleasant St., Stoneham, Mass. 02180, has released an eight-page catalog covering the spectrum of reed relay technology from DIP to axial-lead types. [406]

Oscillators. A short-form catalog from Frequency Sources Inc., 16 Maple Rd., Chelmsford, Mass. 01824, illustrates and includes specifications on a line of solid-state oscillators and sources for both commercial telecommunications and military applications. [407]

Diodes. Microwave diodes, including silicon tuning varactors, multiplier varactors, high-power Gunn diodes, and p-i-n high-voltage diodes are detailed in a six-page short-form catalog that is available from Gigahertz Devices Inc., 16 Maple Rd., Chelmsford, Mass 01824. [408]

Power supplies. Powertec Inc., 9168 DeSoto Ave., Chatsworth, Calif. 91311. A 44-page catalog provides information on the company's standard OEM dc power supplies. Specifications, prices and delivery information are given, in addition to line drawings and mounting-hole dimensions. [409]

Rf sources. An eight-page brochure from Ailtech, 19535 E. Walnut Dr., City of Industry, Calif. 91748, describes high-power rf sources, providing application data. [410]

Reset timers. Cramer Division, Conrac Corp., Mill Rock Rd., Old Saybrook, Conn. 06475. A four-page brochure describes and illustrates the 360 series of reset timers. Specifications, circuit wiring diagrams and ordering information are provided. [371]

Computer systems. Systems Engineering Laboratories Inc., Communications Dept., 6901 W. Sunrise Boulevard, Fort Lauderdale, Fla. 33313, is offering a six-page bulletin

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describing the applications of the model 85/86 real-time computer system. [424]

Thyristors. Unitrode Corp., 580 Pleasant St., Watertown, Mass. 02172, is offering a 60-page application brochure containing 22 design ideas using thyristors. [425]

Connectors. Component Manufacturing Service Inc., 1 Component Park, W. Bridgewater, Mass. 02379. Two product bulletins cover the series 1100 and 1600 control connectors. Line drawings of molds and pin layouts are given. [426]

Switches. A comprehensive design and specification catalog covering a line of slide and rocker switches is being offered by Stackpole Components Co., Box 14466, Raleigh, N.C. [427]

Circuit packages. Flatpack microelectronic circuit packages are described in an eight-page bulletin available from Tekform Products Co., 2770 Coronado Ave., Anaheim, Calif. 92806. [428]

Potentiometer. A two-page publication describing the model 86P dual in-line cermet trimming potentiometer is being offered by the Helipot Division, Beckman Instruments Inc., D 962, Fullerton, Calif. 92634 [430]

Test equipment. A full-line catalog on test equipment is available from Motorola Inc., Communications Division, 1301 Algonquin Rd., Schaumburg, Ill. 60172. The 36-page bulletin covers products ranging from service monitors to tone generators and watt meters. [431]

Laminates. The Mica Corp., 4031 Elenda St., Culver City, Calif. 90230. A 20-page catalog lists specifications of Micaply epoxy-glass laminates and prepregs for multilayer and rigid printed circuits. [432]

Proximity switch. A single-page data sheet describes an industrial infrared proximity switch being offered by DeMott Electronics Co., 7842 Burnet Ave., Van Nuys, Calif. 91405 [433]

Relays. A relay catalog from Potter & Brumfield Division, AMF Inc., 1200 E. Broadway, Princeton, Ind. 47670, contains 226 pages of specifications and engineering data. [434]

Data acquisition. Six-page brochure 450A from B & F Instruments Inc., Cornwells Heights, Pa. 19020, describes the company's SY-256 digital data-acquisition system. [435]

Isolators. A bulletin on plug-in isolators and circulators has been published by Raytheon Special Microwave Devices Operation, 130 Second Ave., Waltham, Mass. [436]

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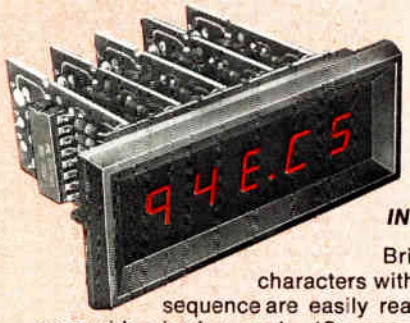

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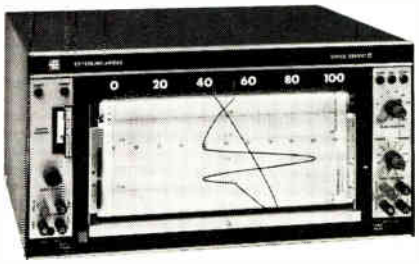

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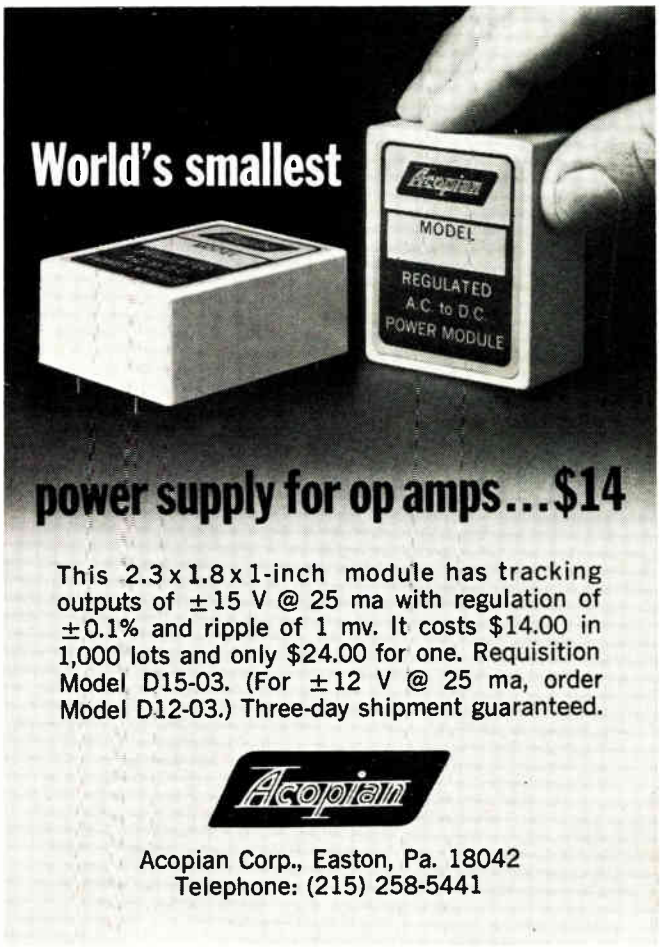

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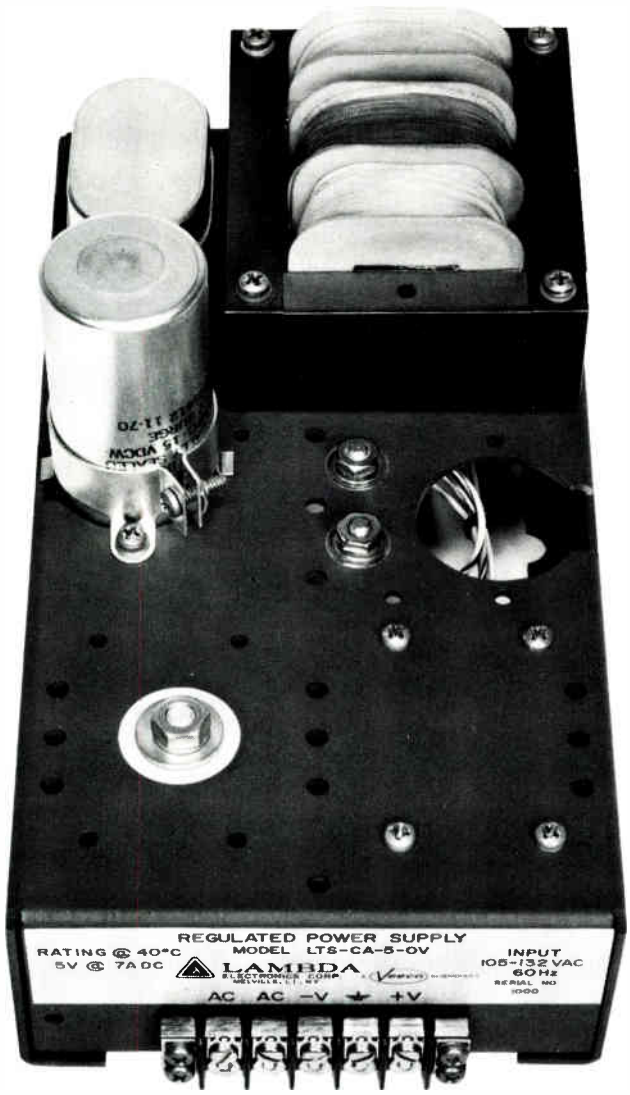

Send for 1973 Power Supply Catalog and Application Handbook

- Only 13 components
- Line regulation—0.02% Load regulation—0.15%
- Ripple and Noise—1.5 mV RMS
- Temperature coefficient—0.01%/°C
- Lambda's long life voltage regulating ferroresonant transformer
- Open construction
- Lambda's 100,000 hours MTBF power hybrid voltage regulator
- MIL-R-11 composition resistors
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- MIL-R-26 type wire wound resistors
- Convection cooled chassis
- Computer grade hermetically sealed 10-year life electrolytic capacitors
- Efficiencies up to 55%
- Under test for listing in Underwriters' Laboratories recognized components index
- 1 Day delivery

5-YEAR GUARANTEE

LTS-CA SINGLE OUTPUT MODELS
$4\frac{29}{32}$" x $4\frac{15}{16}$" x $9\frac{5}{16}$"

MODEL	FIXED VOLT. RANGE VDC	MAX. AMPS AT AMBIENT OF: 40°C	PRICE
LTS-CA5-OV*	5±1%	7.0	$80
LTS-CA-6	6±1%	6.6	80
LTS-CA-12	12±1%	4.4	80
LTS-CA-15	15±1%	4.0	80
LTS-CA-20	20±1%	3.1	80
LTS-CA-24	24±1%	2.6	80
LTS-CA-28	28±1%	2.2	80

*Includes fixed overvoltage protection at 6.8V±10%

LTD-CA DUAL OUTPUT MODEL
$4\frac{29}{32}$" x $4\frac{15}{16}$" x $9\frac{5}{16}$"

MODEL	FIXED VOLT. RANGE VDC	MAX. AMPS AT AMBIENT OF: 40°C	PRICE
LTD-CA-152	±15±1%	2.0	$110
LTD-CA-122	±12±1%	2.0	110

A-C INPUT: 105-132 Vac, 59.7 to 60.3 Hz (STD. Comm'l Line Frequency Spec.), consult factory for operation at other frequencies.

LAMBDA ELECTRONICS CORP.

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